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THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS 1909

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TRANSACTIONS

OF

THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS

VOLUME V.

First Western Meeting, Chicago, Ill., October 18 and 19

Fifth Annual Meeting, New York, N. Y.,
December 6

1909

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OFFICERS

OF

THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS

1908-1909

PRESIDENT.

LOUIS BLOCK.....New York, N. Y.

VICE-PRESIDENTS.

KARL E. VESTERDAHL.....New York, N. Y.

Term expired at Annual Meeting, 1909

HOMER MCDANIEL.....Cleveland, Ohio

Term expires at Annual Meeting, 1910.

TREASURER.

WALTER C. REID.....New York, N. Y.

SECRETARY.

WILLIAM H. ROSS.....New York, N. Y.

DIRECTORS.

J. J. DE KINDER.....Philadelphia, Pa.
F. W. PILSBRY.....Chicago, Ill.
LLEWELLYN WILLIAMS.....Boston, Mass.

Terms expired at Annual Meeting, 1909

THOMAS SHIPLEY.....York, Pa.
JOHN C. WAIT.....New York, N. Y.
KARL WEGEMANN.....New York, N. Y.

Terms expire at Annual Meeting of 1910.

MADISON COOPER.....Watertown, N. Y.
N. H. HILLER.....Carbondale, Pa.
W. H. MANNS.....Waynesboro, Pa.

Terms expire at Annual Meeting of 1911.

PAST AND PRESENT OFFICERS

OF

THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS

PRESIDENTS.

JOHN E. STARR—1905.....New York, N. Y.
W. EVERETT PARSONS—1906.....Newark, N. J.
D. S. JACOBUS—1907.....Hoboken, N. J.
EDGAR PENNEY—1908.....Newburgh, N. Y.
LOUIS BLOCK—1909.....New York, N. Y.

VICE-PRESIDENTS.

H. B. ROELKER—1905.....New York, N. Y.
P. D. C. BALL—1905-1906.....St. Louis, Mo.
JOHN E. STARR—1906-1907.....New York, N. Y.
JAMES WILLS†—1907-1908.....New York, N. Y.
KARL E. VESTERDAHL—1908-1909.....New York, N. Y.
HOMER MCDANIEL—1909-1910.....Cleveland, Ohio

TREASURER.

WALTER C. REID—1905-1909.....New York, N. Y.

SECRETARY.

WILLIAM H. ROSS—1905-1909.....New York, N. Y.

DIRECTORS.

LOUIS BLOCK—1905-1908.....New York, N. Y.
W. EVERETT PARSONS—1905.....Newark, N. J.
EDGAR PENNEY—1905-1908.....Newburgh, N. Y.
D. S. JACOBUS—1905-1906.....Hoboken, N. J.
E. L. PHILLIPS—1905-1906.....New York, N. Y.
W. T. ROBINSON—1905-1906.....Philadelphia, Pa.
L. HOWARD JENKS—1905-1907.....New York, N. Y.
THOMAS SHIPLEY—1905-1910.....York, Pa.
HENRY TORRANCE, JR.—1905-1907.....New York, N. Y.
H. B. ROELKER—1906-1908.....New York, N. Y.
J. J. DE KINDER—1907-1909.....Philadelphia, Pa.
F. W. PILSBRY—1907-1909.....Chicago, Ill.
LLEWELLYN WILLIAMS—1907-1909.....Boston, Mass.
JOHN E. STARR*—1908.....New York, N. Y.
JOHN C. WAIT—1908-1910.....New York, N. Y.
KARL WEGEMANN—1908-1910.....New York, N. Y.
MADISON COOPER—1909-1911.....Watertown, N. Y.
N. H. HILLER—1909-1911.....Carbondale, Pa.
W. H. MANNS—1909-1911.....Waynesboro, Pa.

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* Filled the unexpired term of President Edgar Penney.
† Deceased.

THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.

CONSTITUTION.

NAME, OBJECT AND GOVERNMENT.

C 1. The title of this Society shall be "The American Society of Refrigerating Engineers."

C 2. The object of this Society is to promote the Arts and Sciences connected with Refrigerating Engineering.

C 3. The principal means for this purpose shall be the holding of meetings for the reading and discussion of appropriate papers, and for social intercourse; the publication and distribution of its papers and discussions; and the maintenance of a library of data on refrigeration.

C 4. The Society shall be governed by this Constitution, and by By-Laws and Rules in harmony therewith.

C 5. The Society shall be organized as a Corporation under the Laws of the State of New York.

MEMBERSHIP.

C 6. Persons connected with the Arts and Sciences relating to Refrigerating Engineering may be eligible for admission into the Society.

C 7. The membership of the Society shall consist of Members, Associates and Juniors. Members and Associates are entitled to vote and to hold office. Juniors shall not be entitled to vote nor to be officers of the Society, but shall be entitled to the other privileges of membership.

C 8. Members and Associates are entitled to vote on all questions before any meeting of the Society in person, or by proxy given to a voting member in writing. A proxy shall not be valid for a greater time than six months.

C 9. A Member shall be twenty-six years of age or over. He must have been so connected with Refrigerating Engineering as to be competent as a designer or as a constructor, to take responsible charge of work in his branch of Refrigerating Engineering, or he must have served as a teacher of Refrigerating Engineering for more than five years.

C 10. An Associate shall be twenty-six years of age or over and shall be so connected with Refrigerating Engineering as to be competent to take charge of engineering work, or to co-operate with Refrigerating Engineers.

C 11. A Junior shall be twenty-one years of age or over. He must have had such Refrigerating Engineering experience as will enable him to fill a responsible subordinate position in Refrigerating Engineering work, or he must be a graduate of an engineering school.

C 12. The rights and privileges of every Member, Associate and Junior shall be personal to himself, and shall not be transferable or transmissible by his own act or by operation of law.

ADMISSION.

C 13. All applications for membership as Member, Associate or Junior shall be presented to the Council, which shall consider and act upon each application, assigning each approved applicant to the classification to which, in the judgment of the Council, he is entitled. The name of each candidate thus approved by the Council shall, unless objection is made by the applicant, be submitted to the voting membership for election by means of a letter ballot.

C 14. Associates or Juniors desiring to change their grade of membership shall make application to the Council in the same manner as is required in the case of a new applicant.

C 15. Election to membership shall be by a sealed letter ballot as the By-Laws shall provide. Adverse votes to the number of four per cent. of the votes cast shall be required to defeat the election of an applicant.

C 16. Each person elected shall subscribe to this Constitution, and shall pay the initiation fee before he can be entitled to the rights and privileges of membership. If such person does not comply with these requirements within six months after notice of his election, he will be deemed to have declined election. The Council may, thereupon, declare his election void.

INITIATION FEES AND DUES.

C 17. The initiation fee for membership shall be as follows:

For Members and Associates, five dollars.

For Juniors, five dollars.

A Junior, on promotion to any other grade of membership, shall pay an additional fee of five dollars.

The annual dues for membership shall be as follows:

For Members and Associates, ten dollars.

For Juniors, five dollars for the first six years of their membership, and thereafter the same as for a Member or Associate.

SUSPENSIONS AND EXPULSIONS.

C 18. Any Member, Associate or Junior who shall leave his annual dues unpaid for two years shall, at the discretion of the Council, have his name stricken from the roll of membership and shall cease to have any further rights of membership.

C 19. The Council may refuse to receive the dues of any Member, Associate or Junior who shall have been adjudged by the Council to have violated the Constitution or By-Laws of the Society, or who, in the opinion of the Council, expressed by a two-thirds vote of the entire Council, shall have been guilty of conduct rendering him unfit to continue in its membership; and the Council may expel such person and remove his name from the list of members.

THE COUNCIL.

C 20. The affairs of the Society shall be managed by a Board of Directors chosen from among its Members and Associates, which shall be styled "The Council." The Council shall consist of the President of the Society, who shall be presiding officer; the two Vice-Presidents, Treasurer and nine Members or Associates. Seven Members of the Council shall constitute a

quorum for the transaction of business. The Secretary may take part in the deliberations of the Council, but shall not have a vote therein.

C 21. The Council thus constituted shall regulate its own proceedings and shall be the legal Trustee of the Society. All gifts or bequests not designated for a specific purpose shall be invested by the Council and only the income therefrom may be used for current expenses.

C 22. Should a vacancy occur in the Council, or in any elective office except the presidency, through death, resignation or other cause, the Council may elect a Member or Associate to fill the vacancy until the next annual election.

C 23. The Council shall present at the Annual Meeting of the Society a report verified by the President or Treasurer or by a majority of the members of the Council, showing the whole amount of real and personal property owned by the Society, where located, and where and how invested, and the amount and nature of the property acquired during the year immediately preceding the date of the report, and the manner of the acquisition; the amount applied, appropriated or expended during the year immediately preceding such date, and the purposes, objects or persons to or for which such applications, appropriations or expenditures have been made; also the names and places of residence of the persons who have been admitted to membership in the Society during the last year, which report shall be filed with the records of the Society, and an abstract thereof shall be entered in the minutes of the proceedings of the Annual Meeting.

C 24. An act of the Council which shall have received the expressed or the implied sanction of the membership at the next subsequent meeting of the Society shall be deemed to be the act of the Society, and shall not afterward be impeached by any member.

C 25. The Council may, by a two-thirds vote of the members present, declare any elective office vacant, on the failure of its incumbent for one year, from inability or otherwise, to attend the Council meetings, or to perform the duties of his office, and shall thereupon appoint a Member or Associate to fill the vacancy until the next Annual Meeting. The said appointment shall not render the appointee ineligible to election to any office.

OFFICERS.

C 26. At each Annual Meeting there shall be elected from among the Members and Associates:

A President to hold office for one year.

Two Vice-Presidents, one to hold office for one year, and one to hold office for two years. After the first year one Vice-President to be elected annually for a term of two years.

A Treasurer to hold office for one year.

Nine Members or Associates shall be elected to the Council at the first Annual Meeting, three to hold office for one year, three to hold office for two years, and three to hold office for three years, and at each subsequent Annual Meeting three Members or Associates shall be elected, each to serve three years.

C 27. The election of officers shall be by ballot, as the By-Laws shall provide.

C 28. The term of all elective officers shall begin on the adjournment of

the Annual Meeting of the Society. Officers shall continue in their respective offices until their successors have been installed.

C 29. A President or Vice-President shall not be eligible for immediate re-election to the same office at the expiration of the term for which he was elected.

C 30. The Council, at its first meeting after the Annual Meeting of the Society, shall appoint a Member or Associate to serve as Secretary of the Society subject to the pleasure of the Council. The Secretary shall receive a salary which shall be fixed by the Council at the time of his appointment.

C 31. The President, Secretary and Treasurer shall perform the duties legally or customarily attaching to their respective offices under the laws of the State of New York, and such other duties as may be required of them by the Council.

C 32. A vacancy in the office of President shall be filled by the Vice-President who is senior by age.

MEETINGS.

C 33. The Society shall hold its Annual Meeting in New York City on the Monday preceding the first Tuesday in December, and such other meetings shall be held at such times and places as the Council may appoint. Twenty-five Members and Associates shall constitute a quorum for the transaction of business.

C 34. Special meetings of the Society may be called at any time at the discretion of the Council or shall be called by the President upon the written request of twenty-five members entitled to vote.

C 35. Any appropriation recommended by the Society at a meeting shall not take effect until it has been approved by the Council.

C 36. Every question which shall come before a meeting of the Society or of the Council or a Committee shall be decided by a majority of the votes cast, unless otherwise provided in this Constitution or the By-Laws, or the Laws of the State of New York. The Council may order the submission of any question to the membership for discussion by letter ballot. Any meeting of the Society at which a quorum is present may order the submission of any question to the membership for discussion by letter ballot.

STANDING COMMITTEES.

C 37. The standing committees of the Society shall be:

Finance Committee.

Publication Committee.

Membership Committee.

The members of these Committees shall be appointed by the President from members of the Council who are not officers of the Society.

TRANSACTIONS.

C 38. The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings. Matters relating to politics, religion or purely to trade shall not be discussed at a meeting of the Society, nor be included in the Transactions.

C 39. The Society shall not approve any engineering or commercial enterprise, nor allow its imprint or name to be used in any commercial work or business. No member shall describe himself in connection with the Society in any advertisement other than as a Member, Associate Member or Junior Member.

AMENDMENTS.

C 40. At annual meetings of the Society any Member or Associate may propose in writing for discussion an amendment to this Constitution. Such proposed amendment shall not be voted on at that meeting, but shall be open for discussion and such modification as may be accepted by the proposer. The proposed amendment shall be mailed by the Secretary to each Member and Associate at the time the notice of the Annual Meeting issues, and shall be voted upon at said meeting.

C 41. Such By-Laws shall be enacted as will conform with this Constitution and the Laws of the State of New York and as are required to conduct the business of the Society.

BY-LAWS.

CANDIDATES FOR MEMBERSHIP.

B 1. A candidate for admission to the Society as a Member or as an Associate must make application on a form approved by the Council, upon which he shall write a statement giving a complete account of his qualifications and engineering experience, and an agreement that he will, if elected, conform to the Constitution, By-Laws and Rules of the Society. He must refer to at least four Members or Associates to whom he is personally known.

B 2. Applications for membership from Refrigerating Engineers who are not residents in the United States or Canada and who may be so situated as not to be personally known to four Members or Associates of the Society, as required in the foregoing paragraphs, may be recommended for ballot by four members of the Council, after sufficient evidence has been secured to show that in their opinion the applicant is worthy of admission to the grade which he seeks.

B 3. A candidate for admission to the Society as a Junior must make application in the same manner as provided for Members or Associates, except that he must refer to not less than three Members or Associates to whom he is personally known.

B 4. The references for each candidate for admission to the Society shall be requested to make a confidential communication to the Membership Committee, setting forth in detail such information, personally known to the referee, as shall enable the Council to arrive at a proper estimate of the eligibility of the candidate for admission to the Society.

ELECTION OF MEMBERS.

B 5. The Secretary shall mail to each member entitled to vote, at least thirty days in advance of any meeting, a ballot stating the names and the

respective grades of the candidates for membership in the Society which have been approved by the Council, and the time of the closure of voting. The voter shall prepare his ballot by crossing out the names of candidates rejected by him, and shall enclose said ballot in a sealed blank ballot envelope, which he shall then enclose in a second sealed outer envelope, on which he shall, for identification, write his name in ink. The ballot thus prepared and enclosed shall be mailed or delivered unopened to the Tellers of Election. The Secretary shall certify to the competency and the signature of all voters. On the closure of voting, the Tellers of Election shall first open and destroy the outer envelopes, and shall then canvass the ballots, and certify the result to the meeting of the Society.

B 6. The Tellers of Election shall not receive any ballot after the stated time of the closure of voting. A ballot without the endorsement of the voter written in ink on the outer envelope is defective, and shall be rejected by the Tellers of Election.

B 7. The names of those persons elected to membership, with their respective grades, shall be embodied in a written report, signed by the Tellers, and presented to the next meeting of the Society. The President shall then declare them duly elected to membership in the Society. The Tellers may, through the Secretary, in advance of any meeting, advise each candidate of the result of the canvass of the votes in his case. The names of applicants who are not elected shall neither be announced nor recorded in the Transactions.

B 8. The endorsers of an applicant who has not been elected may, with his consent, present to the Council a written request for a re-submission of his name to ballot. The Council may, in its discretion, by a three-fourths vote of the members present, order the name of the applicant placed on the next ballot for members.

B 9. Each person elected to membership must subscribe to the Constitution, By-Laws and Rules of the Society, and pay the initiation fee before he can receive a certificate of membership in the Society.

ELECTION OF OFFICERS.

B 10. The Secretary shall mail to each member entitled to vote, at least thirty days before the Annual Meeting, the names of the candidates for office proposed for election by the Nominating Committees.

B 11. The names of the candidates proposed by the Nominating Committee or Committees, and the respective offices for which they are candidates, shall be printed in separate lists on the same ballot sheet, each list of candidates to be printed under the names of the members of the particular committee which proposed it.

B 12. The name of any candidate on the ballot may be erased, and the name of any person qualified to hold office written in its stead. The ballot must be voted and canvassed in the same manner as for the election of members.

B 13. In case of a tie in the vote for any officer, the President, or, in his absence, the Presiding Officer, shall cast the deciding vote.

B 14. A ballot which contains more names on it than there are officers to be elected is thereby defective, and shall be rejected by the Tellers.

FEES AND DUES.

B 15. The initiation fee and annual dues of the first year shall be due and payable on notice of election to membership. Thereafter the annual dues shall be due and payable on the first day of December in each year.

B 16. A Member in arrears for one year shall not be entitled to vote until such arrears have been paid. Should the right to vote be questioned, the books of the Society shall be conclusive evidence.

B 17. The Secretary shall present to the Council the name of any Member, Associate or Junior in arrears for more than one year. A person dropped from the rolls for non-payment of dues may, at the discretion of the Council, be restored to the privileges of membership, upon payment of all arrears.

FINANCIAL ADMINISTRATION.

B 18. The Council at its first meeting in each fiscal year shall consider the recommendations of the Finance Committee concerning the expenditures necessary for the work of the Society during that year. The apportioning of the work of the Society among the various standing and other Committees shall be on a basis approved by the Council and in harmony with the Constitution and By-Laws. The appropriations approved by the Council, or so much thereof as may be required for the work of the Society, shall be expended by the various Committees of the Society, and all bills against the Society for such expenditures shall be certified by the Committee making the expenditure, and shall then be sent to the Finance Committee for audit. Money shall not be paid out by any officer or employee of the Society except upon bills duly audited by the Committee, or by resolution of the Council.

FINANCE COMMITTEE.

B 19. The Finance Committee shall consist of three members of the Council appointed for a term of one year. The Committee shall, under the direction of the Council, have supervision of the financial affairs of the Society, including the books of account.

PROGRAM COMMITTEE.

B 20. The President shall appoint a Program Committee from the members of the Council which shall procure professional papers, to pass upon their suitability for presentation, and to suggest topical subjects for discussion at the meetings. The Committee may refer any paper presented to the Society to a person or persons, especially qualified by theoretical knowledge or practical experience, for their suggestions or opinions as to the suitability of the paper for presentation. Papers from non-members shall not be accepted except by unanimous vote of the Committee. The Committee shall arrange the program of each meeting of the Society, and shall have general charge of the entertainments to be provided for the members and guests at each meeting. It shall prohibit the distribution or exhibition at the headquarters or at the meeting places of the Society of all advertising circulars, pamphlets or samples of commercial apparatus or machinery. At the end of each fiscal year the Committee shall deliver to the Secretary for presentation to the Council a detailed report of its work.

PUBLICATION COMMITTEE.

B 21. The Publication Committee shall consist of three members of the Council appointed for a term of one year. The Committee shall review all papers and discussions which have been presented at the meetings, and shall decide what papers or discussions, or parts of the same, shall be printed. At the end of each fiscal year the Committee shall deliver to the Secretary for presentation to the Council a detailed report of its work.

MEMBERSHIP COMMITTEE.

B 22. The Membership Committee shall consist of three members of the Council appointed for a term of one year. It shall be the duty of this Committee:

To receive and scrutinize all applications for membership to the Society.

To seek further information as to the qualifications of any applicant whose evidence of eligibility is not clear to the Committee.

To report to each session of the Council the names of all applicants under consideration, together with the action of the Committee on each.

The Committee shall at once destroy all correspondence in relation to each applicant when his name has been placed on the ballot by order of the Council, or upon the withdrawal of the application.

NOMINATING COMMITTEES.

B 23. A Nominating Committee of five Members or Associates shall be appointed by the President within three months after he assumes office. It shall be the duty of this Committee to send to the Secretary on or before October first the names of consenting nominees for the elective offices next falling vacant under the Constitution. Upon the request of any Member or Associate, the Secretary shall furnish to the applicant the name of such nominees.

B 24. Twenty or more members entitled to vote may constitute themselves a Special Nominating Committee with the same powers as the Annual Nominating Committee. A Special Nominating Committee, if organized, shall, on or before October twentieth, present to the Secretary the names of the candidates nominated by it for the elective offices next falling vacant under the Constitution, together with the written consent of each.

TELLERS.

B 25. The Presiding Officer shall, at the first session of the Annual Meeting, appoint three Tellers of Election of Officers, whose duties shall be to canvass the votes cast, and report the result to the meeting. Their term of office shall terminate when their report of the canvass is presented to the meeting.

B 26. The President, within one month after assuming office, shall appoint three Tellers of Election of Members to serve for one year, whose duties shall be to canvass the votes cast for members during the year, and to certify the same to the President. They shall notify candidates through the Secretary of the result of such election.

B 27. The President shall appoint three Tellers to canvass any letter ballots which shall be ordered by the Council or by the Society.

SECRETARY.

B 28. The Secretary of the Society shall be the Secretary to the Council.

The Secretary shall have charge of the Books of Account of the Society, under the supervision of the Finance Committee.

He shall make and collect all bills against members or others.

All bills against the Society shall be delivered to the Secretary. He shall immediately enter them in the books of Account, and shall immediately deposit such funds as he receives to the credit of the Society in a bank to be designated by the Council.

TREASURER.

B 29. The Treasurer shall make payments only on the audit of the Finance Committee, or upon the direction of the Council, by resolution of that body. He shall furnish a bond for the faithful performance of his duties to such amount as the Council may require, such bond to be procured from an incorporated guarantee company, at the expense of the Society.

TITLES, EMBLEMS, CERTIFICATES.

B 30. Each Member, Associate and Junior shall, subject to such rules as the Council may establish, be entitled on request to a certificate of membership, signed by the President and Secretary of the Society. Every such certificate shall remain the property of the Society, and shall be returned to it on demand of the Council.

B 31. Each proxy authorizing a person to vote for an absent member shall be signed by such absent member, with an attesting witness, and be submitted to the Secretary for verification of the member's right to vote at the meeting at which the right is to be exercised.

B 32. The emblem of each grade of membership approved by the Council shall be worn by those only who belong to that grade. The official stationery shall be used only by officers and committees of the Society for official business.

B 33. The abbreviations of the titles of the various grades of membership approved by the Society are as follows:

For Members—Mem. Am. Soc. R. E.
For Associates—Assoc. Am. Soc. R. E.
For Juniors—Jun. Am. Soc. R. E.

ORDER OF BUSINESS.

B 34. Roll call.
Reading of minutes of previous meeting.
Report of Tellers of Election of Members.
Report of the Council.
Unfinished business.
New business.
Report of Tellers of Election of Officers.
Reading of papers and discussions.

PARLIAMENTARY RULES.

B 35. In all questions arising at any meeting, involving parliamentary rules not provided for in these By-Laws, "Cushing's Manual" shall be the governing authority.

AMENDMENTS.

B 36. These By-Laws may be amended in the same manner as amendments are made to the Constitution.

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PROCEEDINGS

OF THE

FIRST WESTERN MEETING

OF

THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS

CHICAGO, ILL., OCTOBER 18 AND 19, 1909

The American Society of Refrigerating Engineers held a special, the first Western, meeting of the Society in the Stratford Hotel, Chicago, Ill., on Monday and Tuesday, October 18 and 19, 1909. About one hundred and twenty-five members and guests were in attendance. Four sessions were held, Monday morning, afternoon and evening and Tuesday morning, all being called to order and presided over by President Louis Block, New York, N. Y.

First Session, Monday Morning, October 18, 1909

The first session of the meeting was called to order at about 10:45 o'clock A. M. and, as more than a quorum were present, the calling of the roll of members was dispensed with and the meeting was declared open for business.

The minutes of the fourth annual meeting were then read and approved. They were as follows:

MINUTES OF THE FOURTH ANNUAL MEETING

The Society held its Fourth Annual Meeting in the Engineering Societies Building, No. 29 West Thirty-ninth Street, New York, N. Y., on Monday and Tuesday, November 30 and December 1, 1908. Five sessions were held, Monday morning, afternoon and evening, and Tuesday morning and afternoon, all being called to order by President Edgar Penney.

FIRST SESSION, MONDAY MORNING, NOVEMBER 30

The first session of the meeting was called to order at about 10:30 A. M., and after sixty-three members responded to the roll call, a quorum being announced, the meeting was declared open for business.

The minutes of the Third Annual Meeting were then read and approved.

The report of the Tellers of Election of Membership was next received.

They reported that thirteen applicants for membership in the grade of Member, five in the grade of Associate Member and three in the grade of Junior Member had been elected to membership during the year.

The President then declared the successful applicants duly elected to their respective grades and entitled to the rights and privileges of membership if they had complied with the provisions of the Constitution and By-Laws covering new members.

The roll call of new members was next in order and ten were found to be present.

The report of the Council was next heard and accepted.

The report of the committee to conduct the tests on the experimental refrigerating plant of the York Manufacturing Company at York, Pa., was now called for, and John E. Starr, of the committee, stated that as the York Manufacturing Company was obliged to dismantle the test plant before the committee could find it convenient to conduct the tests, the committee had no report to make, and asked to be discharged. President Penney then discharged the committee with the thanks of the Society.

The amendment to the Constitution, creating a special nominating committee, and the amendment to the by-laws, relative to the manner of amending them, introduced at the Third Annual Meeting by Secretary W. H. Ross, were now taken up for final discussion and action. After some discussion they were approved.

A highly interesting address by President Penney was now heard.

The session adjourned at this point for luncheon in the building, arranged for by the Programme Committee.

SECOND SESSION, MONDAY AFTERNOON, NOVEMBER 30

The second session of the meeting was called to order at about 2 P. M. The following three papers were presented at this session:

"The Relative Bacteriological Contents of Can, Plate and Natural Ice Under Various Conditions," by John C. Sparks, New York, N. Y.; "Ethyl Chloride Refrigeration," by C. C. Palmer, New York, N. Y., and "The Construction and Actual Results Obtained from an Ice-Making Plant of Moderate Size," by Charles Dickerman, Philadelphia, Pa.

The report of the Tellers of Election of Officers was now presented. They reported that Louis Block had been elected President; Homer McDaniel, Vice-President; Walter C. Reid, Treasurer, and Madison Cooper, N. H. Hiller and W. H. Manns, Directors.

The President declared the new officers duly elected, and appointed ex-Presidents Starr and Jacobus to escort President-elect Block to a chair beside him.

President-elect Block warmly thanked the members for the honor conferred and the trust and confidence placed in him. He further stated that he felt as happy as President-elect Taft must have felt earlier in the month.

The topic, "What Are the Best Temperatures, According to Modern Practice, for Holding Eggs, Butter, Cheese, Meat and Fruits in Cold Storage Warehouses?" was discussed at this session.

The session then adjourned.

THIRD SESSION, MONDAY EVENING, NOVEMBER 30

The session was called to order a few minutes after 8 P. M. The papers read at this session were:

"Waterproofing in Refrigerating Work," by Edward W. DeKnight, New York, N. Y.; "Standard Methods of Testing Refrigerating Machines," by Dr. D. S. Jacobus, New York, N. Y., and "Reinforced Concrete Freezing Tanks," by William M. Torrance, New York, N. Y.

A vote of thanks was extended Mr. DeKnight and Mr. Torrance for their valuable papers.

Following the reading of the papers a discussion was had on the effects of chloride of calcium brine on piping, tanks, pumps, etc.

The session then adjourned.

FOURTH SESSION, TUESDAY MORNING, DECEMBER 1

The fourth session of the meeting was called to order at about 10 A. M. The following paper was presented at this session:

"Performance of Ammonia Compression Machines," by Dr. Charles E. Lucke, New York, N. Y.

An address on "Recent Investigations in the Handling of Perishable Products by the United States Department of Agriculture," by G. Harold Powell, Washington, D. C., was also heard at this session. A vote of thanks was extended Mr. Powell for his interesting address.

The session then adjourned.

FIFTH SESSION, TUESDAY AFTERNOON, DECEMBER 1

The last session of the meeting was called to order at about 2 P. M.

A report by J. F. Nickerson, Chicago, Ill., on the First International Congress of Refrigerating Industries, which was held in Paris, France, on October 5-12, 1908, was the first business to come before this session. The report was accepted and ordered filed with the records of the Society.

The following three papers were read at this session:

"Does Ammonia Disintegrate in Absorption Plants?" by Dr. H. Dannenbaum, Philadelphia, Pa.; "Refrigeration Applied to Air Supply for Blast Furnaces," by Bruce Walter, Pittsburg, Pa., and "The Portable Refrigerating Plant of the United States Department of Agriculture," by S. H. Dennis, Washington, D. C.

A vote of thanks was given Dr. Dannenbaum and Mr. Dennis for their valuable papers.

The following topics were also discussed at this session:

"What are the Theoretical and Practical Limitations for the Amount of Ice Produced Per Pound of Coal in Distilled Water Can Plants?" "When Storing Eggs, Butter, Cheese, Meats and Fruits in Cold Storage Warehouses, is it Better to Use a Forced Air Circulation or to Pipe the Rooms?"

This closed the business of the meeting, and at this point President Penney made the following remarks:

"I wish especially to thank all of the members for their tolerance and to say to them, in excuse for any shortcomings, that this is my maiden effort at presiding over any meeting. I have been peculiarly gratified at the large attendance, and I certainly have the kindliest feeling towards this Society.

I spent quite a number of years in the refrigerating and ice-making industry, building refrigerating and ice-making machinery, as you know, but lately I have been drifting out of it. But there is one peculiarly pleasant thing that in the meetings of this Society it has been my privilege to attend, both as an officer of the Council and at our open meetings, I have felt perfectly at home, more so than in any other association or society or public relation of my life. Of course, I realize that I am getting to be a back number in refrigeration, and I am well satisfied that the work of the Society will go on, ever of increasing value, and that the younger men who come to the front will do better work than their predecessors. In closing I cannot find language to express just exactly how I feel, but I wish to thank you all for your kind forbearance."

A unanimous vote of thanks was extended President Penney for the able and pleasant way in which he carried out the duties of his office.

The meeting then adjourned.

(Signed) W. H. Ross, *Secretary.*

The report of the Tellers of Election of Membership was next in order. It was as follows:

REPORT OF TELLERS OF ELECTION OF MEMBERSHIP

NEW YORK, N. Y., October 5, 1909.

Mr. Louis Block, President, The American Society of Refrigerating Engineers, 154 Nassau Street, City:

DEAR SIR:—Your Tellers of Election of Membership met this day and canvassed the ballots for new members and beg to report that the following have been elected to membership in the grades indicated:

(101 votes cast, 3 defective for want of signature on outer envelope.)

MEMBERS

Gustav R. Brostrom, York, Pa.
William M. Chatard, Baltimore, Md.
Heywood Cochran, Chicago, Ill.
George H. Fisher, Leavenworth, Kan.
George H. H. A. Geisler, Oakland, Cal.
Albert T. Marshall, Hartford, Conn.
Louis S. Morse, York, Pa.
Adelbert W. Sterrett, Tacoma, Wash.

ASSOCIATE MEMBERS

Robert J. Berryman, Annapolis, Md.
Carl Hausmann, Wellington, New Zealand.
James J. Hinde, Sandusky, Ohio.
Charles A. Hovey, Washington, D. C.
Alexander M. McDougall, Duluth, Minn.
Louis A. Phillips, New York. N. Y.
George H. Sethman, Denver, Col.

JUNIOR MEMBERS

Gustave H. Delareuelle, Oakland, Cal.
Walter W. Sandholt, Oakland, Cal.

CHANGE OF GRADE OF MEMBERSHIP FROM JUNIOR MEMBER TO MEMBER

Alvin H. Baer, Waynesboro, Pa.

Respectfully submitted,

(Signed) H. BORGSTEDT, *Chairman.*
L. HOWARD JENKS } *Tellers of Election*
FRANKLIN H. HERST } *of Membership.*

The President then declared the successful applicants duly elected to their respective grades and entitled to the rights and privileges of membership, if they had complied with the provisions of the Constitution and By-Laws covering new members.

An informal report was now made by the Joint Committee of The American Society of Refrigerating Engineers and The American Society of Mechanical Engineers, appointed to suggest a standard tonnage basis for refrigeration and methods of testing refrigerating apparatus, by John E. Starr of the committee. Mr. Starr stated that the committee begged to report more than mere progress, in that the committee had made a definite step forward by drafting a letter and sending it to the refrigerating engineers, refrigerating machine manufacturers and prominent users of refrigerating machinery, to draw from them an expression of their opinion on one or two points which should really be the starting point of the work of the committee. He then read the letter that the committee had sent out. It is as follows:

JOINT COMMITTEE ON REFRIGERATION

To Refrigerating Engineers, Refrigerating Machine Manufacturers and Users of Refrigerating Machinery:

DEAR SIRS:—A joint committee has been appointed by The American Society of Refrigerating Engineers and The American Society of Mechanical Engineers to suggest a standard tonnage basis for refrigeration. In this connection the committee would like to obtain the co-operation of refrigerating machine builders and all others interested in the art, and therefore submits the following tentative report for your consideration, and invites your comment as to the condenser and refrigeration temperatures and pressures proposed as a standard set of conditions:

The subject will be considered under two heads—

A. The selection of units to measure the cooling effect or the refrigeration produced.

B. The selection of a standard set of conditions under which a refrigerating machine, no matter what its type, shall be run in determining what is herein designated as its commercial tonnage capacity.

The unit adopted to measure the cooling effect, or the refrigeration, is the heat required to melt one pound of ice, which is ordinarily taken at 142 British thermal units. By dividing the refrigeration, measured in British thermal units, by 142, the ice melting capacity in pounds is obtained. The very latest determinations of the latent heat of fusion of ice will be looked up, and if it appears that a more reliable value than 142 British thermal units has been established, the more exact value will be used. The unit for a ton of 2,000 pounds of ice-melting capacity is therefore 284,000 British thermal units. This committee feels that this tonnage unit cannot be improved upon, and herewith recommends its adoption.

The commercial tonnage capacity is the refrigerating effect, expressed in tons of ice-melting capacity, produced by a machine in twenty-four hours when running continuously under the standard set of conditions.

Considering the matter from the standpoint of cost of plant and of steam and water economy, the best set of conditions to adopt seems those which often exist in ice making, namely, that the temperature of the saturated vapor at the point of liquefaction in the condenser be 90 degrees Fahr., and the temperature of evaporation of the liquid in the refrigerator be 0 degree Fahr. This corresponds for ammonia to a condenser pressure of about 168 pounds per square inch above the atmosphere, commonly called gauge condenser pressures, and to a pressure of about 15 pounds per square inch in the refrigerator commonly called gauge back pressure.

The committee will devise a set of conditions or factors for the purpose of calculating the actual refrigerating capacity under various sets of conditions as to condenser and suction pressures, so that when other temperatures and pressures are used a proper correction may be made.

F. E. MATTHEWS, *Secretary.*

Mr. Starr further stated that over fifty replies had been received from the letter, and that the replies will be of great assistance to the committee. In concluding his remarks, he stated that the committee is simply trying to get at the nearest standard of refrigeration and the nearest method of testing refrigerating apparatus that it could, to report them to the two Societies. The committee's report will give the consensus of opinion of the refrigerating engineers and builders of refrigerating machinery, and he hoped that the work of the committee would bring the manufacturer and buyer of refrigerating machinery and the refrigerating engineer a little closer together. The committee's report was accepted.

The Nominating Committee then announced its nominations for the offices falling vacant at the next annual meeting. They were as follows:

REPORT OF NOMINATING COMMITTEE

NEW YORK, N. Y., October 1, 1909.

Mr. Louis Block, President, The American Society of Refrigerating Engineers, 154 Nassau Street, City:

DEAR SIR:—Your Nominating Committee reports the following nominations to fill the offices falling vacant at our annual meeting on December 6th, in accordance with paragraph B23 of the By-Laws:

President—Roderick H. Tait, St. Louis, Mo.

Vice-President—Charles E. Lucke, New York, N. Y.

Directors—E. N. Friedmann, New York, N. Y.; Gardner T. Voorhees, New York, N. Y.; Charles Dickerman, Philadelphia, Pa.

Treasurer—Walter C. Reid, New York, N. Y.

We attach herewith the acceptances of our nominees.

Very truly yours,

(Signed) EDGAR PENNEY, *Chairman.*

D. S. JACOBUS.
JOHN E. STARR.
PETER NEFF.
W. EVERETT PARSONS.
} *Nominating Committee.*

President Block now appointed the following Resolutions Committee to draft resolutions on the deaths of Francis H. Boyer, Henry Blethen and Alfred Siebert, and to report at the annual meeting in New York on December 6, 1909: Theodore O. Vilter, Milwaukee, Wis.; John E. Starr, New York, N. Y., and F. W. Pilsbry, Chicago, Ill.

The address of President Block was now received with marked attention and applause. It appears in these Transactions as one of the papers of this meeting.

The following two papers were presented at this session: "The Cold Storage Warehouse as a Fire Hazard," by Joseph B. Finnegan, Chicago, Ill., and "Water Purification for Ice and Refrigerating Plants," by J. C. William Greth, Pittsburgh, Pa.

A vote of thanks was extended both Mr. Finnegan and Mr. Greth for their interesting papers.

The session adjourned at this point for luncheon, as the guests of the Chicago members of the Society.

Second Session, Monday Afternoon, October 18, 1909

The second session of the meeting was called to order shortly after 2 o'clock P. M. The first business to come before this session was the appointing of a Special Resolutions Committee to draft a letter of greeting to the American Meat Packers' Association in convention at the Hotel LaSalle. The President appointed John C. Atwood, St. Louis, Mo.; Walter L. Hill, Boston, Mass., and R. H. Tait, St. Louis, Mo., on this committee.

The following three papers were presented at this session:

"What Is the Meaning of the Term Efficiency?" by Peter Neff, Canton, Ohio; "The Ice Factory of the Future," by Victor H. Becker, Chicago, Ill., and "The Refrigeration of Dairy Products," by John A. Ruddick, Dairy and Cold Storage Commissioner of Canada.

The Special Resolutions Committee appointed to draft a letter of greeting to the American Meat Packers' Association now made

its report by offering the following letter, which was accepted and ordered sent by the meeting:

CHICAGO, ILL., October 18, 1909.

The American Meat Packers' Association, in Convention Assembled in the Hotel La Salle, Chicago, Ill.:

GENTLEMEN:—The American Society of Refrigerating Engineers, in convention assembled in the Stratford Hotel, Chicago, Ill., extends you its greetings and best wishes for the success of your deliberations, and, remarking the mutuality of our interests, cordially invites such of your members as feel they can spare the time from your own important discussions to all of the courtesies of our meeting.

Respectfully,

(Signed) LOUIS BLOCK, *President.*

(Signed) W. H. ROSS, *Secretary.*

The following topics were also discussed at this session:

"The Internal Combustion Engine as a Prime Mover in Refrigerating and Ice-Making Plants," and "What Can Be Done to Prevent Electrolytic Action Upon Steam Condenser Tubes When Sea Water is Used for Condensing Purposes?"

The session then adjourned.

Third Session, Monday Evening, October 18, 1909

The third session was called to order shortly after 8 o'clock P. M.

The following two papers were read at this session:

"The Flooded System and Its Application to Ice Making and Refrigerating Plants," by H. Rassbach, Milwaukee, Wis., and "Autogenous Welding," by Fred W. Wolf, Jr., Chicago, Ill.

A motion prevailed thanking Mr. Rassbach for his splendid paper.

Dr. Charles E. Lucke also made a few remarks on "The Economy of Wet versus Dry Compression and Its Dependence on the Properties of Saturated Ammonia Vapors" that were highly interesting.

The session then adjourned.

Fourth Session, Tuesday Morning, October 19, 1909

The last session of the meeting was called to order at about 10 o'clock A. M.

The following four papers were presented at this session:

"Cold Storage Temperatures and Arrangement of Cold Storage Warehouses for Handling All Classes of Merchandise," by Walter L. Hill, Boston, Mass.; "The Thermodynamics of Saturated Vapors

and Related Energy Problems," by Dr. J. E. Siebel, Chicago, Ill.; "The Comparative Value of Direct and Indirect Refrigeration for Cold Storage Plants," by Nelson J. Waite, Cleveland, Ohio, and "Approximate Cost of Making Ice in Plants of Different Sizes, Each Operating Under Similar Conditions," by A. P. Criswell, Chicago, Ill.

J. C. Goosmann, Chicago, Ill., also gave an extremely interesting illustrated lecture on "Low Temperatures in Surgery and Microscopy."

A hearty vote of thanks was extended Dr. J. E. Siebel for his very valuable paper.

Dr. Charles E. Lucke, New York, N. Y., presented the following resolution, which was unanimously accepted:

RESOLUTION ON PHYSICAL CONSTANTS

WHEREAS, The members of the American Society of Refrigerating Engineers have come to a realization of the inaccuracy of the physical constants used in calculating the dimensions and performance of refrigerating and ice-making apparatus; and

WHEREAS, It is of great importance not only to the members of The American Society of Refrigerating Engineers, but also to all industries depending upon mechanical refrigeration, that these constants be carefully determined; and

WHEREAS, The determination of the values of these constants is a difficult and expensive undertaking, beyond the scope of any individual and beyond the scope of the usual university equipment; and

WHEREAS, The United States Government maintains physical laboratories with men and equipment suitable for these determinations; and

WHEREAS, The United States Government has contributed to the advancement of agricultural and other industries to the extent of millions of dollars yearly,

Be it Resolved, That the President of The American Society of Refrigerating Engineers appoint a committee to secure the co-operation of all the industries dependent upon refrigeration, and proceed, together with their representing committees, to confer or communicate with the Secretary of Commerce and Labor, with a view to securing an order on the directors of the laboratories under the charge of the Department of Commerce and Labor to make correct and accurate determinations of the physical constants necessary in calculating the dimensions and performance of refrigerating machinery.

In accordance with the resolution of Dr. Lucke, the President appointed Dr. Charles E. Lucke, chairman; Dr. D. S. Jacobus, New York, N. Y.; John E. Starr, New York, N. Y.; F. E. Matthews, New York, N Y., and Gardner T. Voorhees, New York, N. Y., on this committee.

Professor K. G. Smith, of the University of Illinois, who was a guest of the Society, suggested that his institution be included in the resolution of Dr. Lucke, and Victor H. Becker, Chicago, Ill., moved that the President appoint a committee from the Illinois members of the Society to request the University of Illinois to undertake experiments along the line suggested by Dr. Lucke in its engineering experiment station. The motion carried.

The President appointed the following Illinois members on this committee: Victor H. Becker, Chicago, Ill.; A. P. Criswell, Chicago, Ill., and Otto Luhr, Chicago, Ill.

The Illinois Steel Company, through General Superintendent William A. Field, extended an invitation to the members of the Society to visit its plant in South Chicago on the afternoon of Tuesday, October 19. A large number of the members availed themselves of this invitation.

G. J. Patitz extended a cordial invitation on behalf of the Peter Schoenhofen Brewing Co., Chicago, Ill., to the members of the Society to visit its brewery while in Chicago, and a number enjoyed a trip to the brewery.

There being no further business before the meeting, President Block closed the meeting with the following remarks:

"Now, gentlemen, I thank you for your attention, and I want to assure you that it has been a pleasure to preside over the deliberations of such genial spirits as I have found in you. I thank you."

MEMBERS AND GUESTS ATTENDING CHICAGO MEETING

Acton, F. C., Chicago, Ill.
Arens, Otto A., Pittsburg, Pa.
Ashton, Walter S., St. Louis, Mo.
Atwood, J. C., St. Louis, Mo.
Baars, E. S. H., Milwaukee, Wis.
Bacon, C. J., Chicago, Ill.
Bardenheuer, Wm. C., Chicago, Ill.
Becker, Victor H., Chicago, Ill.
Becker, Jr., Victor H., St. Louis, Mo
Bird, Thomas A., Chicago, Ill.
Bishop, A. C., Detroit, Mich.
Block, Louis, New York, N. Y.
Bonnell, C. E., Chicago, Ill.
Bracken, J. H., Winona, Minn.
Clifton, P., Pomeroy, Ohio.
Cochran, Heywood, Chicago, Ill.
Cooper, Madison, Watertown, N. Y.
Criswell, A. P., Chicago, Ill.
Criswell, C. A., Chicago, Ill.
DeHart, Jr., J. S., Newark, N. J.
Dickermann, Hudson, New York, N. Y.
Engel, B., Chicago, Ill.
Erippittes, K. F., Chicago, Ill.
Finnegan, Joseph B., Chicago, Ill.
Fisher, G. H., Leavenworth, Kan.
Goerner, G. W., New York, N. Y.
Goosmann, J. C., Chicago, Ill.
Greene, V. R. H., New York, N. Y.
Greth, J. C. W., Pittsburg, Pa.
Haire, D. E., Philadelphia, Pa.
Heard, A. E., Chicago, Ill.
Hickey, F. A., Chicago, Ill.
Hill, Walter L., Boston, Mass.
Hiller, N. H., Carbondale, Pa.
Holden, D. L., New York, N. Y.
Holzbaur, W. J. Kansas City, Mo.
Howe, Arthur E., New York, N. Y.
Hunter, George C., Cleveland, Ohio.
Jamison, Jr., J. V., Hagerstown, Md.
Johnson, Albert, St. Louis, Mo.
Kerbel, C. Joseph, Louisville, Ky.
Kilian, Justus, Milwaukee, Wis.
Kirker, B. M., Chicago, Ill.
Knuth, Edward C., Chicago, Ill.
Krum, Charles L., Chicago, Ill.

Langdon, George M., New York, N. Y.
Leinert, Charles H., South Chicago, Ill.
Levey, John, Chicago, Ill.
Lightfoot, C., Buffalo, N. Y.
Livezey, John R., Philadelphia, Pa.
Lord, R. E., Louisville, Ky.
Louis, J. S., Cincinnati, Ohio.
Lucke, Charles E., New York, N. Y.
Luedicke, A. H., Milwaukee, Wis.
Luhr, Otto, Chicago, Ill.
Mark, F. Lloyd, Chicago, Ill.
Marshall, J. B., Salt Lake City, Utah.
McPartlin, S. E., Chicago, Ill.
McPike, E. F., Chicago, Ill.
Mott, Walter, Chicago, Ill.
Neff, Peter, Canton, Ohio.
Nickerson, J. F., Chicago, Ill.
Norden, George H., Detroit, Mich.
Nusbaum, Lee, Philadelphia, Pa.
Nygren, William, Chicago, Ill.
Osborne, W. L., Chicago, Ill.
Patitz, G. J., Chicago, Ill.
Peters, L. A., Milwaukee, Wis.
Pilsbry, F. W., Chicago, Ill.
Place, A. C., St. Louis, Mo.
Rassbach, H., Milwaukee, Wis.
Reeder, Charles, Pleasant Hill, Mo.
Reilly, J. P., New York, N. Y.
Rice, D., Chicago, Ill.
Riley, W. H., Wilmington, Del.
Robbins, H. S., St. Louis, Mo.
Robertson, G. A., Louisville, Ky.
Rosmann, J. L., Milwaukee, Wis.
Ross, W. H., New York, N. Y.
Roth, Arthur J., Chicago, Ill.
Ruddick, J. A., Ottawa, Can.
Russell, F. S., Chicago, Ill.
Schapper, Walter, Chicago, Ill.
Schroeder, W., Chicago, Ill.
Scovel, J. C., Chicago, Ill.
Siebel, E. A., Chicago, Ill.
Siebel, J. E., Chicago, Ill.
Shenton, W. H., Chicago, Ill.
Smith, K. G., Urbana, Ill.
Stacy, George B., Chicago, Ill.
Starr, John E., New York, N. Y.
Stevenson, S. P., Chester, Pa.
Stone, J. H., New York, N. Y.
Stratton, Harrison D., Philadelphia, Pa.
Tait, R. H., Chicago, Ill.
Thomas, John H., New York, N. Y.
Turner, R. E., Chicago, Ill.
Van der Vaart, S. S., Chicago, Ill.
Vilter, Theodore O., Milwaukee, Wis.
Visscher, William Lightfoot, Chicago, Ill.
Vogt, Henry, Louisville, Ky.
Waite, N. J., Cleveland, Ohio.
Ward, Edwin J., Chicago, Ill.
Weidinger, A. E., Chicago, Ill.
Weintraub, Wistar M., Philadelphia, Pa.
Westerlin, J. M., Chicago, Ill.
Whelan, R. A., Chicago, Ill.
Wolf, Fred. W., Chicago, Ill.
Wolf, Jr., Fred. W., Chicago, Ill.
Wolf, George P., Chicago, Ill.
Wright, F. E., Cleveland, Ohio.
Young, C. H., New York, N. Y.
Younglore, T. G., Chicago, Ill.
Zilker, Charles A., San Antonio, Tex.

THE BANQUET.

The banquet was held on Tuesday, October 19, at 7 p. m., at the Stratford Hotel, over fifty gathering around the festive board, where an attractive menu was spread. After partaking freely of the good things placed before the guests, President Block called for order and introduced ex-President John E. Starr as the toastmaster of the evening. Mr. Starr invited all members to rise and drink to the continued prosperity of the Society and spoke briefly of its ideals and hopes. President Block responded. Among the others who responded to toasts were R. H. Tait, St. Louis, Mo., who spoke of the future of the Society and predicted that Europe would come to America for information on refrigerating practice, which was later in the evening answered by Cecil Lightfoot, Buffalo, N. Y., and formerly of London, England, when he spoke on the liquid air plant

at Buffalo and the uses of liquid air in the production of oxygen and nitrogen; and, referring to Mr. Tait's prediction, declared it to be already true in at least one line, viz., the use of refrigeration for drying the air blast for blast furnaces. Charles E. Bonnell, Chicago, Ill., in his usual happy vein, introduced amusing allusions to matters presented at the convention. J. F. Nickerson, Chicago, Ill., explained the organization and aims of the American Association of Refrigeration and its affiliation with the International Congress. Junius H. Stone, New York, N. Y., responded to a toast on the next International Congress of Refrigerating Industries. J. C. Atwood, St. Louis, Mo., related some of his experiences while on a trip for his health through Norway and Sweden. William Lightfoot Visscher, Chicago, Ill., who was a guest of the Society, told a number of amusing incidents of his experiences. John H. Thomas, New York, N. Y.; A. P. Criswell, Chicago, Ill., and C. H. Young, New York, N. Y., also took part.

The following attended the banquet:

Allan, James, Omaha, Neb.
Atwood, John C., St. Louis, Mo.
Bardenheuer William, Chicago, Ill.
Bird, Thomas A., Chicago, Ill.
Bishop, A. C., Detroit, Mich.
Block, Louis, New York, N. Y.
Bonnell, Charles E. Chicago, Ill.
Cochran, Heywood, Chicago, Ill.
Criswell, A. P., Chicago, Ill.
Erlandson, Gustav, Chicago, Ill.
Goosmann, J. C., Chicago, Ill.
Hickey, F. A., Chicago, Ill.
Hill, Walter L., Boston, Mass.
Hiller, N. H., Carbondale, Pa.
Holden, D. L., New York, N. Y.
Howe, Arthur E., New York, N. Y.
Johnson, Albert, Chicago, Ill.
Kerbel, C. Joseph, Louisville, Ky.
Langdon, George M., New York, N.Y.
Leinert, Charles H., Chicago, Ill.
Lightfoot, Cecil, Buffalo, N. Y.
Luhr, Otto, Chicago, Ill.
Mark, F. Lloyd, Chicago, Ill.
Nygren, William, Chicago, Ill.
Nickerson, J. F., Chicago, Ill.
Osborne, W. L., Chicago, Ill.
Patitz, G. J., Chicago, Ill.
Place, A. C., St. Louis, Mo.
Riley, W. H., Wilmington, Del.
Ross, W. H., New York, N. Y.
Tait, Roderick H., St. Louis, Mo.
Schapper, Walter, Chicago, Ill.
Thomas, John H., New York, N. Y.
Starr, John E., New York, N. Y.
Stone, J. H., New York, N. Y.
Stratton, H. D., Philadelphia, Pa.
Van der Vaart, S. S., Chicago, Ill.
Waite, Nelson J., Cleveland, Ohio.
Weintraub, W. M., Philadelphia, Pa.
Whelan, R. A., Chicago, Ill.
Wolf, Fred W., Chicago, Ill.
Wolf, Jr., Fred W., Chicago, Ill.
Wolf, George P., Chicago, Ill.
Wright, F. E., Cleveland, Ohio.
Young, Conrad H., New York, N. Y.
Younglove, T. G., Chicago, Ill.

PAPERS OF THE

FIRST WESTERN MEETING

OF

THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS

AT CHICAGO, ILL

No. 64.

PRESIDENTIAL ADDRESS—COST REDUCTION OF ICE MAKING PLANTS

By Louis Block, New York, N. Y.

It is an honor and a pleasure to preside at the first meeting in the West of The American Society of Refrigerating Engineers, and in Chicago, of which Mark Twain has said: "A city where they are always rubbing the lamp, and fetching up the genii, and contriving and achieving new possibilities. It is hopeless for the occasional visitor to try to keep up with Chicago; she outgrows his prophecies faster than he can make them. She is always a novelty, for she is never the Chicago you saw when you saw her the last time."

The same thing may be said of refrigerating engineering and of the refrigerating industries. We are no longer in our infancy. We have now grown to vigorous manhood and have arrived at a more conservative age; still, we are plunging ahead, making improvements, spreading out, and anyone who wants to keep up with the refrigerating industries must travel fast. We dare not stand still, and our aim will be in the future, as it has been in the past, to not only improve and simplify machinery and apparatus, but to make improvement in the line of cutting down the cost of refrigerating and ice making plants.

I do not mean to convey the idea that manufacturers charge too much for their goods; their profits are small enough, and we all know that but too often they have no profits at all. Manufacturers, by applying modern methods of manufacture in the production of refrigerating machines and apparatus, have done much to reduce the cost, and the consumer can to-day purchase a refrigerating plant for one-third the price which he paid 25 years ago.

The cost of ice making plants, while it has been reduced, has not been reduced in like proportion, and we must look to the engineer to devise means for cutting down the cost by simplifying the process of ice making, or by other means. He must rub Aladdin's lamp and contrive and achieve new possibilities. Earnest application in any direction by intelligent and trained engineers will always produce beneficial results. We may—yes, we will—make mistakes, but

that should only spur us on to better efforts, for he who never makes mistakes will never achieve any great success.

Don't let us assume the standards of the present day as being unalterably fixed; don't let us assume that it must take from 40 to 60 hours to freeze a marketable cake of ice in a can; don't let us assume that it must take from five to seven days to freeze marketable ice on a plate. Don't let us cling to the idea that the ratio of a ton of ice per day to compressor displacement per minute, as now established, must be adhered to, nor that the ammonia evaporating surface may not be changed.

If we succeed in reducing the cost of manufacture of ice making plants we open another great field of usefulness for the engineer and the manufacturer. Northern cities are but scantily supplied with ice making plants, for the reason that natural ice can be harvested and marketed at a lower cost than manufactured ice, and, while natural ice plants on the banks of rivers and lakes near northern cities increase every year, the ice making plant is nearly entirely neglected. Why is this so? It is because to erect a natural ice plant costs so very much less than a machine ice plant. The former is built where real estate is sold by the acre and the latter where it is sold by the square foot. A natural ice plant with storage for 20,000 tons of ice costs from $30,000 to $35,000, including the real estate and water rights. Compare this with its equivalent, a one-hundred-ton machine ice plant in cities like Chicago, Boston or New York, and it is easily understood why it is difficult to persuade the natural ice man to go into the ice manufacturing business. He is willing to pay something for the certainty of production, for the always assured harvest. If the cost of harvesting natural ice plus meltage and breakage and cost of transportation from place of harvest to the market exceeds the cost of production of machine made ice in the city he is willing to pay a sum the interest per annum of which would be equivalent to the difference in cost of the natural and the manufactured ice at the place of sale. After he has accurately figured what he could afford to pay for an ice factory in a large city and he finds the sum he is asked to pay exceeds what he fixed in his own mind by from 30 to 50 per cent he abandons the idea of going into the ice manufacturing business and says: "I will wait until ice plants get cheaper." Who can blame him? He may feel just as strongly as we feel that it is desirable, especially for family use, to supply filtered or distilled water ice instead of the natural product, and he would like to supply it, but he cannot afford it, at least not now, and he waits until ice plants get cheaper.

If an ice making plant in a large northern city could be operated winter and summer, if it were within the reach of economical possibilities to store the ice made during the winter months, its cost would not appear excessive, but, with the price of a 25 x 100-foot lot at $15,000, it cannot be thought of. An insulated building covering the entire lot and 45 feet high, with an ice hoisting and lowering apparatus and refrigerating pipe equipment, would cost in the neighborhood of $17,000, and would hold 2,000 tons of ice. The cost of storing 2,000 tons of ice would therefore be equivalent to the interest for the entire year of $32,000, plus the taxes and insurance, cost of handling the ice and cost of refrigeration. It will be seen at a glance that storing ice in a large city is not practicable and we must look in other directions for relief.

It seems necessary, even imperative, that the refrigerating engineer should devise means to reduce the cost of buildings and real estate of ice making plants in cities, without, however, crowding machinery and apparatus together and thus interfere with efficiency, easy handling and operation. I mean to say, the engineer must devise a plant which will do all the ice plant of the present day will do, but do it in less space, and he must devise means to improve the ice plant of the present day and bring it upon a more equable footing with the ice plant of the future.

Let us work in the direction of producing marketable ice in 24 hours, instead of from 40 hours to 7 days, without increasing the size of compressors or increasing the heat-absorbing surface; let us cut away from the old methods and produce something new.

Looking along the corridor of time, where we see Twining, Carré, Gorrie, Beath, Linde, Lightfoot, Windhausen, the two Boyles, Holden, Skinkle, Neff, Ballantine, Behn, Wolf and De La Vergne, and seeing what has been accomplished since these men began their activities, who can say that with the training of the present day refrigerating engineer, energetically bent upon improvements in a given direction, radical changes in the production of ice are not within the realm of possibilities?

No. 65.

COLD STORAGE WAREHOUSE AS A FIRE HAZARD.

By Joseph B. Finnegan, S. B., Chicago, Ill.

(Non-Member of the Society)

The subject of my paper, "Cold Storage Warehouse as a Fire Hazard," is of importance to insurance people, just as any subject which has to do with the matter of fire causes and fire prevention and extinction is of importance to the insurance man. It is, perhaps, not necessary to point out at this time and place the fact that the subject of fire protection is of importance to others than insurance people—especially to the business men and the engineers who are themselves interested in the ownership or the operation of plants which may be subject to damage or complete destruction by fire.

The tremendous fire loss in this country is not due simply to the fact that we have had a Chicago conflagration, a Baltimore conflagration, and a San Francisco conflagration. The large and increasing destruction of values which our records show year by year, even when we have no single great fire, tells the story of faulty methods of building construction, of hazardous processes insufficiently safeguarded, of neglect of provisions for preventing the spread of fire and providing for its extinction. Thus we have every year a total fire loss comparable with that in the greatest of city conflagrations. This destruction of values is one of the most important of the economic problems that the country has to face, and the gravity of the problem is increased by the prevailing tendency to pass it by as a matter which is of interest mainly to the insurance companies.

Fire insurance provides a means for distributing the loss. The destruction of values is not made good. The endeavors of insurance organizations to reduce the fire loss can be successful only through the co-operation of the community at large. To you, as members of a national engineering association, I wish to speak as to men whose professional and business duties are such that you are able to do valuable work toward the improvement of conditions that threaten to become even more serious than they are at present.

In our discussion of the cold storage warehouse from the point

of view of fire protection, we may consider, first, its hazards; second, its structural features, and third, its protective equipment.

The hazards that are peculiar to plants of this sort are not especially numerous. Ammonia gas is not combustible in the ordinary sense of the word, but is capable of burning when it contains atomized or vaporized oil which it has taken up in the compression process, or possibly if it contains certain other foreign materials of a combustible character. Indirectly, however, the ammonia may contribute to the hazard of the risk on account of the possibility of rupturing the tanks or the cylinders which may be at rather high pressures. An accident of this sort is likely to cause fire by injuring the boilers, electric equipment, or the like; and, moreover, if the explosion is itself caused by a rise in temperature resulting from a fire which has started from some other cause, the total amount of damage caused by the fire will be materially increased by the destructive effect of the explosion. Moreover, the escape of ammonia gas may impede the work of extinguishing the fire by making it impossible for the firemen to approach near enough to use their hose streams effectively. The direct and indirect hazards of the ammonia may be reduced by avoiding the use of open lights in the neighborhood of compression machines, and by automatic relief and stop valves which will lessen the danger of explosion and diminish the probability of the excessive leakage of gas to the room in case an accident does happen.

The power plant will usually be more hazardous than other parts of the establishment, because, in addition to the refrigerating machinery proper, it will contain the boiler and engine equipment or the electrical machinery which may be used to produce power. The hazards of this portion of the plant may be reduced to a minimum by proper installation, care in management, handling of fuel and ashes, storage of oils or liquid ammonia drums, and proper disposal of oily waste. The electrical hazard may exist in portions of the plant other than the power house if electric lighting is employed or if electric motors be installed in the warehouse. Strict adherence to the rules of the National Electrical Code will result in reducing the electrical hazard to a minimum. To this end careful attention should be given to the wiring, fixtures and cut-outs, and the electrical installation should be, as far as possible, protected from the influence of ammonia gas, traces of which may be in the atmosphere in some plants. It is probably needless to say that a properly installed and properly cared for system of electric lighting is preferable to gas.

There are some fundamental principles which should be considered in the construction of buildings for cold storage purposes, as well as of those designed for other classes of occupancy. Certain other points are peculiar to the type of building that we are at present discussing. In the first group of requirements we may discuss the construction of the exterior walls, floors and roof, the protection of floor openings, subdivision of the risk into separate fire sections if the building is of large area, isolation of the more hazardous portions—as, for instance, the power plant—and protection against exposing fires.

The exterior walls will usually be of brick, with or without a steel framework. The floors and roof should be of fireproof construction, with tile or concrete arches carried on steel members which are adequately fireproofed. If such construction is not employed—and usually it is not—a heavy mill floor and roof may be substituted. Such a floor would be made of splined or tongued and grooved planks, in two thicknesses, with waterproofing material between. The fact that combustible material is employed in the construction of such a floor becomes less important in view of the fact that it will be of comparatively great thickness, and may be protected from fire to an appreciable extent by the material which is applied to its upper and lower surfaces to serve as insulation. This feature may also make it possible to construct the wooden portion of the floor of a single thickness of heavy planking instead of two thicknesses, inasmuch as the insulating material may be arranged to give the waterproof qualities which are aimed at in the use of a two-ply floor with waterproofing material between the plies.

Assuming that the floor is made impervious to water, it is wise to go a step further in the endeavor to localize the damage that may be done by water discharged into a particular section of the building. This result may be accomplished by providing drains to carry away water falling upon the floor, and by giving the floor a slight inclination toward the drains and away from doors or floor openings.

Floor openings have an important influence upon the spread of fire within a building, inasmuch as they may furnish a path by which the fire may travel readily from one floor to the next. The protection of such openings by means of an enclosing fireproof shaft, with all openings into the shaft protected by approved fire doors, will reduce the floor opening hazard to a marked degree. In some cases it is possible to eliminate floor openings entirely by installing the stairways and elevators in a tower outside the building proper and com-

municating with it at each floor by openings provided with standard fire doors.

If a fire occurs in a building, the manner in which the building is subdivided may determine the amount of property destroyed. It is desirable that in a building of considerable area this idea of subdivision should be carried out as far as practicable. It is frequently the case that the demands of the business itself will necessitate partitions or division walls, and if this condition exists, the fire protection engineer's advice would be to see that the construction of the division walls is such that they are efficient fire stops, and that they are provided with satisfactory fire doors at each opening. If the division of the plant into separate and practically independent fire sections is desirable in the main portions of the risk, where the fire hazard is, perhaps, approximately the same in each of the fire sections, the same logic will indicate the especial desirability of such treatment of the more hazardous portions as will isolate them from other parts. The application of this principle will ordinarily mean that the power plant, with its very appreciable hazards, should be so constructed and so located that a fire originating there will not spread to other portions of the plant.

Closely allied to the question of preventing spread of fire from one section of the risk to another is the question of protecting the building as a whole from ignition as the result of exposure to a fire in a neighboring building. The exposure hazard will, of course, depend in large measure upon the distance separating the two buildings and upon the construction and occupancy of the exposing building. It is obvious that in many cases these features are not within the control of the owner of the exposed building; but, nevertheless, he can reduce the danger to his own property by reducing the number of window openings in the exposed wall, or if this be not practicable, by equipping each exposed window with a form of protective device adapted to the circumstances of the case, as, for instance, with swinging shutters, wired glass windows, or steel rolling shutters, possibly with the addition of open sprinklers.

The structural features noted above are of importance in the case of cold storage warehouses, just as they are in other classes of buildings; but in their practical working out some peculiarities of the type of building in question may have an important bearing upon the manner in which the principles stated above are adapted to the case in hand.

In the first place, the insulating material employed in the walls, partitions, floors and ceilings may be affected by fire, or may even

contribute to the spread of fire. It is no part of our present purpose to consider the insulating efficiency of the various methods that may be employed, but we will confine ourselves to the consideration of them from the standpoint of fire protection. If double brick walls be employed—that is, two separate walls with an intermediate air space, either with or without some filling material supposed to have insulating value—it would appear that the fire-retardant properties of the wall will not be affected, assuming that the two parts of the wall are of sufficient thickness to insure stability. If the attempt is made, however, to carry out the same idea, using a concealed air space enclosed on one or more sides by wood sheathing, the resulting construction is objectionable in the extreme, since it provides a channel through which fire may spread and in which it is beyond easy reach. Even though the enclosed space may be filled with an insulating material of an incombustible character, there is more than a probability that there will still be an opportunity for fire to travel along the inner surfaces of the combustible sheathing, especially if the filling has settled or shrunk to any extent.

Hollow tile is not open to the objection just noted, inasmuch as the interior air spaces are entirely surrounded by incombustible material. It may be noted, however, that hollow tile directly exposed to fire is subject to damage as a result of unequal expansion, which causes the shelling off of the exposed face. I understand that the present attitude of refrigerating engineers is favorable to the use of a type of insulation that depends upon the inclusion of minute air spaces in the body of the material itself, the substances used in this way being worked up into the form of sheets or blocks. Such sheet or block insulations are made of cork, or of some type of mineral fibre, in the latter case probably with the addition of a certain proportion of combustible fibrous material. The material is applied to the inner face of the wall, or to the floor or ceiling, in one or more layers, some waterproof cementing material being used to cause adhesion of the layers to the backing and to each other, and to protect the exposed surface. Theoretically, the material used in the construction of the blocks or sheets should be absolutely incombustible. In practice, however, it has been learned that it may be possible to use organic material which is combustible to a certain extent, but which will burn with difficulty in the compact form in which it is used for insulation, and will not carry fire or continue to burn if the exposure to fire ceases.

The practice of covering the exposed face with cement will be of great value in protecting the insulation proper from fire, pro-

vided that the finish is incombustible and stable under fire conditions. This indicates the advisability of using a good cement mortar rather than an asphalt or pitch cement, and the use of the less combustible material is preferable also between the layers of insulation and on the face of the backing. Under severe fire conditions, the effects of calcination and expansion may be to cause even good cement mortar to lose its stability, and if a hose stream be directed upon the material after its exposure to fire, it is especially likely to show serious injury. Even under this severe condition the insulation itself, if of the better grades, may act to some extent as a fire stop, although it will require repairs to put it again in serviceable condition. The Underwriters' Laboratories have already taken up the investigation of materials of this character from the standpoint of fire protection, and some actual fire tests have been made. It is to be expected that the further development of the work along this line at the laboratories will give information of value.

In the matter of subdivision of the cold storage plant into separate fire sections, the needs of the business itself anticipate the suggestion of the fire protection engineer in many cases, and we find the plant cut up into numerous storage rooms. If the partitions are properly constructed of non-combustible material, as brick, tile, or concrete, and the insulating material employed is satisfactory from the point of view of fire protection, we have to consider only the matter of suitable protection for the necessary door openings in the partitions. Since most such openings are provided with insulating doors, of considerable thickness and fitting the opening very closely, they are fairly satisfactory fire stops. Their efficiency can be increased by a sheet-metal covering, which will protect the combustible material of which the door is made.

The isolation of the power plant, which has already been mentioned as a desirable feature in practically all classes of risks, involves some rather unusual features in a cold storage risk. Even if the power plant is so placed that a fire starting in it cannot extend to the warehouse proper, the result of a fire which will put the source of power out of service may be very serious, on account of the consequential damage to the stored merchandise, due to the interruption of the refrigerating process. It would seem that the practice of installing refrigerating machines in duplicate or triplicate, which has been dictated by the desire to prevent loss resulting from interruption to the operation of the machinery, should be carried a step farther, and the reserve machines so located that they are not likely to be affected by a fire which puts the regular machines out of

service. This may involve the sub-division of the power house by fire walls. In order that the duplication of apparatus shall be most effective, it should cover, not only the ammonia machinery, but also boilers, engines, generators, motors, and all necessary auxiliaries.

Protection against exposing fires is likely to be simpler in cold storage plants than in most other classes of buildings, on account of the small number and limited size of the windows in exterior walls.

Passing to the subject of extinction of fire, there is one class of protective equipment that has demonstrated its efficiency in various types of risks to such an extent that it easily ranks first. I refer to automatic sprinkler protection. Obviously, if such a system is installed in a building where low temperatures are maintained, the use of the ordinary wet system is inadmissible, and the dry pipe system should be employed. In this type of sprinkler installation the sprinkler piping in the building normally contains air under pressure, and the lowering of the pressure as a result of the opening of a sprinkler head allows the automatic operation of a valve, usually in the basement, which admits water into the piping. The system should be installed throughout all parts of the plant, particular care being taken to see that no corner or recess is out of range of water thrown by the sprinkler head, and, what amounts to nearly the same thing, that fire starting anywhere will be able to affect an operative sprinkler head.

The sensitiveness of the automatic sprinkler head under the conditions that exist in plants which employ a fan system for causing circulation of the air has recently been the subject of much discussion. Without attempting to go over all the ground that has been covered during recent months in the very interesting discussion of this subject, we may point out that the fusing point of the solder used in the ordinary sprinkler head is approximately 160 degrees Fahr., and that no satisfactory sprinkler head having an appreciably lower operating temperature has been put on the market as yet. It is obvious that a fire might do a considerable amount of damage in a cold storage room before the temperature of the sprinkler heads would rise to such an extent that they would open, if the heads are constantly chilled by the cold air current from a fan, and if also the horizontal currents in the neighborhood of the fire tend to prevent the natural rise of the heated air. Considering the problem solely from the viewpoint of the fire protection engineer, it would seem obvious that, in plants of this type, satisfactory operation of the sprinkler system cannot be assured without the adoption of some means of arresting the cold air currents which retard the heating

of the sprinkler head. It may be that the solution of the problem lies in the use of thermostats operating at a temperature considerably below that at which a sprinkler head opens, and installed so that they control dampers in the air ducts, or possibly shut down the fan itself. The possibility of such an arrangement is worth careful consideration. The danger involved in the presence of a condition that impairs the efficiency of the most valuable of the available extinguishing equipment is undeniable. The detailed working out of the means for overcoming the danger calls for earnest co-operation between the people most interested, the cold-storage plant owner and the insurance man. It is to be expected that the problem will be solved in such a way as to retain the maximum efficiency of the sprinkler system with the minimum interference with the working efficiency of the cold storage plant.

In addition to the thermostats, which may be installed for the purpose noted above, it is desirable that each room be equipped with thermostats designed to give an alarm if fire occurs. The dry pipe valve of the sprinkler system will also in practically every case be equipped with an alarm device.

Suppose that we assume that our plant is in compliance with the best practice in all respects—that its construction is good—that its hazardous portions are isolated—that it is provided with satisfactory protective equipment for detecting and extinguishing fires. All of these things may lose much of their value if the administration of the plant is lax in matters affecting fire protection. Constant attention, regular inspections, and what we may call "good housekeeping" are essential. The premises should not be left unguarded at any time, the watchman should be on duty at all times when the plant is not in operation, and his records should be inspected, to insure the faithful performance of his duties. The automatic sprinkler system should be inspected frequently in order that its value may not be impaired or destroyed by low pressures, closed valves, failure of tank supply, or other cause. The frame of mind of the man in charge of the plant should be that of one who feels that, in spite of care to foresee and forestall mishaps, he may find that some point in his armor is weak, and that he can never rest secure in the thought that he has perfected his safeguards and may relax his own vigilance. Proper construction and suitable equipment are costly in money and in brains. It is fitting to protect this two-fold investment by a judicious expenditure of money to preserve the efficiency of the fire protective features, and by a proper expenditure of thought, without which the whole may become valueless.

DISCUSSION.

V. R. H. Greene.—I would like to ask Mr. Finnegan what he considers the relative fire risk in the case of the ordinary mill-construction building as compared with a fireproof building, taking into consideration good insulation, an efficient sprinkler system and the use of reinforced concrete?

Joseph B. Finnegan.—That bears closely upon the question of what would be the proper rate in the case of such buildings. It is a subject on which I would not want to express any definite opinion. I would say, however, that a mill-constructed building, with mill floors and brick walls, would be a pretty satisfactory building from an insurance standpoint. As to its efficiency as compared with the fireproof building, I would really not care to express an opinion.

Junius H. Stone.—I would like to ask Mr. Finnegan what the fire insurance companies are willing to do, or what they are doing, in the way of rates in such a case as this at the present time, for a cold storage man who puts up a house in accordance with the best practice as he has outlined it, and another man who does fairly well, but who puts in the old type of building with boards and air-spaces in his insulation, and generally adopts the practice of fifteen years ago? Is any difference made in the rate in favor of the man who expends twenty per cent. more on his plant in the way of fire safeguards as against the man who does not?

Joseph B. Finnegan.—That is a question that I thought would arise, although I was rather hoping that it would not. The question of fire insurance rates is not an engineering question. It is a question on which there is a chance for a good deal of feeling, and I am appearing before you today as the representative of an organization which has nothing to do with rates, and, without appearing to be discourteous, I should like to be excused from answering questions pertaining to rates. I think you will see my position in the matter.

Junius H. Stone.—It has occurred to me that in asking a refrigerating engineer to design a building that would present a minimum fire risk and impress its value upon his clients, inducing the latter to expend considerably larger sums of money than they would otherwise do, there should be a sort of *quid pro quo* from the other side of the fence. It would be very much easier for the engineer to get his clients to spend additional money if there were some recognition by the insurance people of the benefit to them. The general practice of the Board of Underwriters in such cases as that is what?

Joseph B. Finnegan.—The general practice of the underwriters

in regard to the matter of making rates is to take into account in great detail all the features which have to do with the construction and the hazard of the risk. The schedules which are employed are extremely detailed and take into consideration a large number of different factors. As to whether or not these are taken care of to the satisfaction of the various interests you gentlemen represent, I am not in a position to say. Personally, I am not familiar with the rates on cold storage warehouses; I have to do simply with the engineering aspect of the problem.

John E. Starr.—I should like to ask if, assuming the refrigerating plant is isolated, a fire occurs in the ice plant, and as a result the refrigeration is stopped and goods are damaged by reason of the stoppage of the refrigeration and not damaged by fire or water, is it not a fact that in such a case the insurance companies would be liable for the resulting damage?

Joseph B. Finnegan.—I am not in a position to speak authoritatively on that point, but my opinion is that there will usually be some clause in the policy covering that point explicitly, either assuming or disclaiming consequential damages.

John E. Starr.—I have heard a great deal of dispute on how the Board of Underwriters regards wire glass. I have heard a great deal said on both sides of the subject, and I would like to know something from an authoritative source on that point.

Joseph B. Finnegan.—I have personally conducted a number of experiments with wire glass and on wire-glass windows. Undoubtedly wire glass has a decided value, but it also has certain very definite limitations. Most wire glass is principally plate glass, a quarter of an inch thick, with a sheet of wire mesh in the center. It has a great advantage over ordinary glass of the same thickness, in that it will stay in place even after it is cracked. It will crack just as readily as ordinary glass; it will fuse at the same temperature as ordinary glass.

I have been told by wire-glass manufacturers that glass becomes liquid at between 1,200 and 1,300 degrees Fahr. That is assuming that it is in a furnace where that temperature is really maintained on all sides of the mass of glass. At the Underwriters' Laboratories, where tests are conducted in such a way that the glass is heated on only one side and is open to the outer air on the other side, the glass will stand in place until a temperature of from 1,500 to 1,650 degrees Fahr. is reached; but at a temperature above that it will soften to such extent that it falls out of the frames. It is undoubtedly very much superior to ordinary glass, but it is not in a class with a brick

wall; it is not in a class with concrete or with a good tile partition. Several different brands of wired glass are approved, but in every case the approval permits the use of the glass as a protection against only moderate exposures. Wire glass is not considered a satisfactory protection against a planing-mill exposure, or against other similar hazard. It does not take the place of first-class shutters.

Wire glass will crack when it is exposed to heat. It will crack into very small fragments if it is suddenly cooled by the application of water while it is hot; but even those very small fragments will stay in place unless it is subjected to serious impact from the fire stream, or unless the temperature is raised to such a point that the glass actually softens and falls out.

John E. Starr.—As I understand it, whenever glass has to be used, the insurance companies would regard wire glass as better than ordinary glass. That is about as far as we can go.

Joseph B. Finnegan.—For instance, the enclosure of the elevator shaft in this building is largely of wire glass. Theoretically, that shaft ought to be made of brick, with fire-doors at each floor. It is not built to satisfy the insurance people altogether. The shaft must be lighted, and that means you must have some transparent material; and wire glass is the best transparent material than can be used in that way.

Otto Luhr.—As to the electric wiring in cold storage warehouses, I should like to have you give us a few points on that. Should some of the wires be placed in conduits, and what wires are to be used for drop-lights, and so on? Are arc lights permissible?

Joseph B. Finnegan.—I will take the last question first. It would be desirable, in risks where there is any possibility of having an inflammable vapor in the air, that you have no kind of open light, which would indicate that ordinary arc lights are not to be used. The enclosed arc with a double globe may be safe, or an incandescent lamp, preferably with a double globe, would be satisfactory. Undoubtedly the use of a conduit system for the wire is preferable to an exposed system of wiring, inasmuch as it protects the insulation of wires from injury.

If drop-lights are used, an especially heavy insulation is required, similar to what is known as packing-house cord, where two wires are thoroughly insulated in the first place and then twisted together, and additional heavy insulation is placed over the wires. The fixtures should be substantial, and the number of switches ought to be reduced to a minimum. You cannot carry that out to an extreme, of course, in your electric lighting system.

Heywood Cochran.—I should like to know whether the brine circulation system is supposed to be a better fire risk than the direct-expansion?

Joseph B. Finnegan.—I do not see why there should be any great difference from the point of view of fire hazard. I know it is considered rather ludicrous by refrigerating engineers to hear other people talk about the possibility of ammonia in the air of a refrigerating plant. I really have not the idea that the atmosphere of a cold storage plant is reeking with ammonia fumes.

Robert A. Whelan.—I should like to ask a question in regard to the wiring of cold storage rooms. What is your opinion in regard to using 220 or 110-volt current? In a plant where power is developed and a great many motors are used for operating auxiliaries and for other reasons, it may be desirable to use the higher voltage. Is there any difference in the fire risk whether you use 220 or 110-volt current?

Joseph B. Finnegan.—I believe it is ordinarily considered that if the entire installation is adapted to the higher voltage there would be no appreciable difference in the hazard. It would mean a different kind of lamp, it might mean a greater care in locating and insulating the switches, it might mean some difference in the fuses; but if the equipment is adapted to a 220-volt current I believe that it is not any more hazardous than the 110.

Robert A. Whelan.—In other words, you mean that if care is exercised in locating and insulating the switches and proper fuses are used, and if care is exercised in other respects, the risks are about equal?

Joseph B. Finnegan.—Yes.

No. 66.

WATER PURIFICATION FOR ICE AND REFRIGERATING PLANTS.

By J. C. William Greth, Pittsburgh, Pa.

(Non-Member of the Society)

In the process of refrigeration or ice-making, water is the medium by which the heat absorption is effected, and upon its purity depends the efficiency of the apparatus for the transfer of heat. Water in the refrigerating or ice-making plant is the all-important agent; as water, it acts as the heat transferring medium; as steam, it operates the entire plant; as ice, it is the finished product. But in spite of these important functions we rarely find particular consideration given to the water, outside of the factors of cost, quantity and temperature.

On account of the large quantities required, the cost of procuring a supply usually influences the selection. The fact that the efficiency of heaters, boilers, condensers, etc., may be seriously affected by the impurities in the water is apparently often overlooked. Since the efficiency and economy of the plant depend upon the transfer of heat by means of water, it becomes a matter of great importance to carefully examine the water to determine the impurities.

The most noticeable results from the impurities of water are the scaling and corroding of boilers, auxiliaries, condensers and coolers; contamination of distilled water for can ice, and more frequent washing out and refilling of freezing compartments in plate ice. Few of the natural supplies are pure, since water has the power of carrying impurities not only in suspension, but also in solution. The impurities in water are due to carbonic acid and other impurities absorbed by water from the air when falling as rain, and to the nature of the soil, rocks, vegetation, sewage and industrial refuse with which it may come into contact. All natural waters contain two classes of impurities, organic and inorganic, which may be either in suspension or in solution.

The organic impurities are of vegetable and animal origin, taken up by flowing over the ground or by direct contamination with sew-

age and industrial refuse. It is these organic impurities, together with suspended matter, which have brought about the necessity for the purification of water for domestic use. Organic matter is of minor importance in the ice or refrigerating plant as compared with the inorganic impurities. It is true that it may affect the character of scale and may form some scale in boilers and on condensers, and in some waters may be corrosive. It undoubtedly affects to some extent the appearance, odor and taste of can ice, and it may have a pathogenic effect in plate ice. However, if the water is soft, efficient sedimentation and filtration will practically remove the organic and suspended impurities, and make the water suitable for any purpose in the ice or refrigerating plant.

The suspended inorganic impurities consist of clay, silica, iron, alumina, etc., in the form of mud and silt. The most common soluble inorganic impurities are lime, magnesia, iron and sodium in combination with carbonic, sulphuric, hydrochloric and, in some instances, nitric acid; a small amount of silica, iron and alumina oxides; some free carbonic acid, and in some cases free sulphuric acid, in others hydrogen sulphide. These soluble impurities consist of both non-scale-forming and scale-forming substances.

The non-scale-forming substances consist of the sodium salts; these are not objectionable in cooling or condensing waters, nor are they objectionable in boiler feed water unless present in large quantities.

The soluble scale-forming substances may be divided into two classes, those which cause temporary hardness and those which cause permanent hardness. Temporary hardness is due to the carbonates of lime, magnesia and iron, the precipitation and removal of which begin at temperatures below the boiling point and is practically completed by continued boiling at atmospheric pressure. Permanent hardness is due to the sulphates, chlorides and nitrates of lime, magnesia and iron, which, as a rule, are not precipitated or removed at temperatures below the boiling point.

Another group of the soluble impurities in water, those which cause corrosion, includes the acids and those substances which, by heat alone, or by heat and concentration, react, liberating corrosive acids.

CONDENSING AND COOLING WATER.

The impurities in water used for cooling and condensing purposes cause waste and expense for the following reasons:

Reduced efficiency of coolers or condensers, due to the insulating effect of scale; cost of labor required for cleaning condensers

and coolers; cost of repairs necessitated by corrosion or by injuries due to cleaning; high temperature of condensed refrigerating media, shortage of condensed steam, high temperature of water to fore cooler; loss due to reduced capacity and earning power while shut down for cleaning or repairs.

The deposit of scale on the condensing and cooling surfaces is due to a decrease in the solubility of those salts which cause temporary hardness, and which are held in solution by carbonic acid as bicarbonates. When heat is applied, especially with agitation, carbonic acid is driven off; this changes the bicarbonates into the practically insoluble carbonates, which are then precipitated. The higher the temperature to which the water is raised, the greater is the resultant precipitation, the maximum occurring at the boiling point.

Water used for cooling and condensing purposes is rarely, if ever, raised to the boiling point, therefore at no time is there likely to be a complete precipitation of the carbonates; but any rise in temperature tends to reduce the solubility of the carbonates, therefore as soon as heat is applied precipitation begins, which increases with the rise of temperature. The range of temperature for a well water passing over an atmospheric ammonia condenser is, say, from 56 degrees Fahr. to about 85 degrees Fahr., which represents the average temperature of the water flowing off the condenser, but not the extreme temperature to which some of the water is raised.

Assuming that the gas enters the ammonia condenser at 220 degrees Fahr., then a film of water in passing over the condenser is, in all probability, heated to, say, 200 degrees Fahr., which starts a precipitation of the carbonates. The further increase of temperature of the water in the same manner in passing over the exhaust steam condenser, where the average temperature of 120 degrees Fahr, is attained, results in a much greater precipitation; therefore, more scale then accumulates in the ammonia condenser. The flat cooler of the ice plant may also be scaled in the same manner.

The following analyses illustrate the precipitation due to rise of temperature in passing over condensers. Analysis 1 is that of a well water having a temperature of about 56 degrees Fahr., and analysis 2 that of the same water after passing over atmospheric condensers for ammonia and exhaust steam where a temperature of about 120 degrees Fahr. was attained.

TABLE I.

Solids in Water. (Figured in Grains per U. S. Gal.)	Analysis 1. Well Water.	Analysis 2. Same Water After Passing Over Condensers.
Volatile and Organic Matter	2.90	2.70
Silica	.45	.45
Iron and Alumina Oxides	.25	.20
Calcium Carbonate	23.00	15.50
Calcium Sulphate	.68	.71
Magnesium Sulphate	12.72	12.69
Magnesium Chloride	2.52	1.44
Magnesium Nitrate	.30	.27
Sodium Chloride	5.78	7.12
Total Solids	48.60	41.08
Suspended Matter	1.80	5.85
Free Carbonic Acid	.55	.66
Incrusting Solids	39.92	31.26
Non-incrusting Solids	5.78	7.12

These analyses show a reduction of about eight grains in the hardness of the water. The plant using this water is of fifty tons ice-making capacity. On this basis, allowing two gallons per minute per ton capacity, there will be deposited on ammonia and exhaust steam condensers about 7 pounds of scale per hour.

In the double pipe and shell type condensers and coolers the cooling surface is reduced as the thickness of scale increases. For instance, if the 1¼-inch water pipe of a double pipe ammonia condenser be coated with ⅛ inch of scale, the internal area per foot of length will be reduced from 52 square inches to 42.6 square inches, or a loss in the actual cooling surface of over 18 per cent.

While it is true that the surface of condensers can be cleaned, it is expensive, and is done only periodically, affording at best only temporary relief; for the scale begins to form immediately after each cleaning, with the resultant losses in efficiency and increased load on the remainder of the apparatus.

The corrosion of condensing and cooling surfaces is sometimes a very serious danger, and expensive as well. It may be caused by the presence of sulphuric acid or similar acids in the water, or from carbonic acid with dissolved air. Hydrogen sulphide, which is often found in well waters, will cause corrosion; and magnesium chloride will, by the heat obtained in condensers, dissociate into hydrochloric acid and magnesium hydrate, the acid causing corrosion and the magnesium hydrate forming scale. A similar dissociation with like results takes place with iron sulphate.

THE STEAM BOILER.

The steam boiler forms a necessary adjunct to the refrigerating or ice-making plant, as it is the usual source of power. The waste and expense due to a scale-forming and corroding water in the boilers is an important factor in the cost of producing a ton of ice or a ton of refrigeration. They may be summed up as follows:

Reduced evaporation, due to the insulating effect of scale.

Cost of labor required for cleaning the boilers and auxiliaries.

Cost of repairs to boilers, due to corrosion or necessitated by their being subjected to overheating on account of the heating surfaces being scaled.

Loss of efficiency and earning power of improved furnaces and stokers installed to increase evaporation, which correspondingly increases the concentration of impurities, thus forming a greater deposit of scale or more active corrosion, and hence a greater reduction in the efficiency and life of the boilers.

Loss due to increased depreciation of boilers, due to scale and corrosion; also, increased deterioration, due to cooling and again putting into service, especially when rapid cooling and forced firing are necessary.

Cost of tube-cleaning machines, repairs to them, interest and depreciation on the money invested, and labor and power required for operating them.

Cost of boiler compounds, or any substances introduced into the boiler to prevent corrosion and the adherence of the scale-forming matter to the shells and tubes; also, the effect of some compounds on the quality of ice produced.

Loss due to the investment in spare boilers to be put into commission when it is necessary to take boilers out of service for cleaning or repairs.

Waste of fuel, due to heat lost in cooling a boiler for cleaning or repairs, and that required to again bring it into service.

Loss due to reduced efficiency of boiler auxiliaries, especially in the feed water heaters and economizers, resulting in lower temperatures of feed water.

Reduced heating surface in water tube boilers, due to reduced tube diameters and a consequent reduction in the volume of the water space.

Impurities introduced into distilled water, causing odors or discolorations in the ice.

Loss by reduced capacity from lack of steam, due to scale, corrosion, or imperative repairs.

In view of these effects, all of which are traceable to the impurities in water, the character of the water used for boiler feed merits careful consideration, not only on account of the effects in the boiler, but also for the effects upon economy and efficiency in the operation of the entire plant.

Many ice or refrigerating plants operate only to full capacity about six months per year, so in many cases the boiler capacity is just about sufficient to carry the maximum load, on the assumption that the boilers can be overhauled during the winter. This is true enough, but the waste, expense and loss of capacity during the six months' operation are constantly increasing, reaching a maximum at the end of the season, and are more than sufficient to pay a handsome return on the cost of obtaining a good boiler water.

For condensers and cooling surfaces many waters are satisfactory, which in boilers may cause scale or corrosion, or both, due to the higher temperatures obtained and concentration resulting from evaporation.

WATER PURIFICATION.

To combat the evils of scale and corrosion many methods and devices are used. Most of them are at best but partially successful, due to improper application or to being directed against the effect instead of the cause.

Boiler compounds, when correct chemically, are efficient for the prevention of corrosion, but when employed to overcome scale their use results in an increase of the amount of impurities; so, no matter how carefully a compound may be specialized, no real removal of the scale-forming substances can be effected. All that can be accomplished is to change scale and scale-forming substances into sludge and soluble impurities, neither of which can be effectively removed by the blow-off.

With mechanical tube cleaners scale only is removed, and that periodically. All that is accomplished is the removal; there is no attempt at prevention.

Automatic skimming and filtering cleaners and like apparatus deal only with substances resulting from the reactions brought about by heat and concentration in the boiler. They are not effective against corrosion and only to a limited extent against scale.

Heater purifiers deal with the cause, but in an irrational manner, and only partially remove the impurities against which they

are directed. Even with the use of excessive amounts of chemicals, all that they accomplish is a distribution of scale and sludge in pipe lines, pumps and boilers. This distribution occurs because the temperatures attained and the time usually allowed are not sufficient to complete precipitation in the heater. This necessitates cleaning not only the heater purifier, but also the pipe lines, pumps and boilers.

The more any apparatus whose function is to impart heat to water is used as a scale collector, the less will be its efficiency as a heat conductor. The use of intermediate apparatus, condenser or boiler as a catch-all for the impurities in water, and the removal of the accumulated deposits by chemical or mechanical means, is a common example of the irrational makeshift methods directed against the effects of bad water. Any attempt at purifying water after it is put to use is dealing with effects, not with the cause; and although the principle of some of the methods may be correct, the application is wrong, and therefore the desired result cannot be obtained.

There is a practical and efficient method of combating scale and corrosion, and that is to remove from the water those substances which produce these effects. The process is rational in application, the results certain, and the cost in every case is but a small fraction of the advantage gained. This process deals with the problem in the manner prescribed by the chemist for bringing about, by the use of proper reagents, those reactions that neutralize or precipitate corrosive acids and change the soluble salts of lime, magnesia and iron into insoluble precipitates for removal by sedimentation and filtration; all of which is accomplished before the water is used.

To properly soften and purify a water is a much more delicate process than it is generally understood to be, because the amount of impurities which have to be removed bears but a small relation to the volume of water. For instance, 10 grains of impurities per gallon of water are less than two-one-hundredths of one per cent. Such being the case, it becomes absolutely necessary to introduce the reagents in correct amounts to avoid having a great excess or deficiency. The correct treatment for the purpose for which the water is to be used can easily be determined by means of simple color tests. An accurate analysis of the water is of vital importance for determining the treatment employed and the apparatus required to obtain the best results.

The cost of softening a water will, of course, depend upon the amount of reagents required, and these, in turn, depend upon the amount and kind of impurities. It is readily understood that it costs more to remove 25 grains of carbonate of lime than it does to

remove 10 grains; not because the method is any different, but because a greater quantity of reagent is required to bring about the precipitation. But, to offset the increased expense, there is a much greater increase in savings.

A water softening system, to give results, must be designed so as to meet all requirements for complete chemical reaction. These requirements may be summed up as follows:

An accurate chemical treatment, accomplished by the introduction of the proper reagents in exact quantities to react with the impurities in a definite quantity of water.

Thorough mixture of the reagents with the water to insure complete chemical reaction.

Accelerated chemical reaction, brought about by a thorough mixture of reagents with the water, and by mixing the sludge of previous softening with the new finely-divided precipitate.

A complete chemical reaction, brought about by a thorough mixture of the reagents with the water and by having the apparatus large enough for each particular water to be treated in order to allow sufficient time for all the necessary reactions to take place, and to have the apparatus so designed that every part of it is effective.

A rapid sedimentation, by having the new, finely-divided precipitate weighted by the sludge of previous precipitation, to cause it to settle more rapidly and perfectly.

A perfect clarification, by allowing time for sedimentation and final clarification by perfect filtration.

There are two types of water softening and purifying systems in use, the continuous and the intermittent. In the continuous system the water is treated by introducing the reagents with proportional feeding devices as it flows into the apparatus. In the intermittent system the water is treated, at intervals, in measured quantities, with exact weights of reagents.

With the continuous apparatus the introduction of the reagents is only proportional to the quantity of water; therefore, adjustment must be made in the quantity of reagents introduced to meet every variation in the water. This being the case, an error must necessarily occur whenever the quality of the water varies, since no automatic device to adjust the quantities of reagents in proportion to the various impurities in water has been invented, and it is not probable that one ever will be devised. On account of this limitation, the continuous apparatus is neither adaptable to all waters nor for all uses.

This type of apparatus will usually answer all requirements

for condensing water, as high temperatures and concentration need not be taken into consideration, and accurate treatment is not so essential.

In the intermittent system measured quantities of water are treated all the time, and the exact quantities of reagents are weighed out; therefore, it is possible to accurately treat any water, no matter how it may vary in quality or in the quantity used. This type of apparatus meets every requirement for the perfect softening and purification of any water for any use.

The introduction of the reagents in correct amounts is the vital function of the process of softening and purifying water. This must be done by the operator, who can, with certainty and greater ease, obtain more accurate results with the intermittent system than with the continuous.

For boiler feed, to give the best results the water must be clear. For condensing purposes this is not so essential, but desirable. It is not possible to always obtain a clear water with an excelsior or wood-fibre filter. Every water softening system, for boiler feed or for condensers of the closed type, should be equipped with a sand filter, which can be washed and be so designed that all suspended matter will be removed from the water as it leaves the water softening system.

An ideal arrangement for ice or refrigerating plants having a bad water that scales or corrodes condensers, auxiliaries and boilers is to install a water softening system to remove from the water those impurities which affect the condensers, and then in a second system complete the treatment for boiler feed. The necessity for such an arrangement is due to the fact that, as a rule, the water requirement for condensers is considerably greater than for the boilers. Further, the cost of treating water for condensers is less than for boiler feed. So it would become an item of waste to treat all the water for condensers in the same manner as for boilers, unless use could be made of the water that would justify the expense. When cooling towers are in use it is generally advisable to fully treat the make-up water and that used for boiler feed.

Water for the greatest economy in steam boiler plants should be free from corrosive acids or from salts which tend to form such acids, and the lime and magnesia salts should be less than 3 grains per gallon. If such a water is available, but contains suspended matter, it should be clarified by sedimentation and filtration. If the water contains more than four grains of scale-forming salts, it should be softened and purified, to reduce the soluble scale-forming

impurities and organic substances to a point where an analysis will show quantities about as follows: Volatile and organic matter, 1 grain; silica, ½ grain; oxides of iron and alumina, trace; calcium carbonate, 2 grains; magnesium hydrate, ½ grain; but no other compounds of lime and magnesia. Suspended matter should never be more than a trace. Such a water will not form scale, because the amount of scale-forming salts left in solution is too small, even with concentration, to form anything but a light sludge. This sludge can be kept at a minimum by proper blowing off, and the boiler, no matter how long it is in operation, will, on being opened, have the appearance of having been whitewashed; the iron of the boiler can be exposed anywhere by rubbing with the finger or washing out with a good pressure. Corrosion cannot take place, because the water is slightly alkaline and does not contain either corrosive acids or salts, which, by dissociation or reaction, will form corrosive acids.

The following analyses, 3 and 4, illustrate what is accomplished by the proper softening and purification of a water for boiler feed:

TABLE II.

Solids in Water. (Figured in Grains per U. S. Gal.)	Analysis 3. Well Water.	Analysis 4. Softened and Purified Water.
Volatile and Organic Matter	1.55	.29
Silica	.35	.20
Iron and Alumina Oxides	.25	trace
Calcium Carbonate	13.12	1.90
Calcium Sulphate	.61	.....
Magnesium Carbonate	3.90	.....
Magnesium Chloride	1.30	.....
Magnesium Hydrate	.....	.50
Sodium Sulphate	.....	.71
Sodium Chloride	.21	1.87
Sodium Hydrate	.....	.08
Total Solids	21.29	5.55
Suspended Matter	.75	trace
Free Carbonic Acid	.10	none
Incrusting Solids	19.53	2.60
Non-incrusting Solids	.21	2.66

The treatment has reduced the organic matter, iron, lime and magnesia salts to the limit of their solubility, thus making an ideal feed water; and, further, the steam formed from this water is in the best possible condition for any purpose in the ice or refrigerating plant.

Water for condensing and cooling purposes should be free from

all corroding acids or those substances which, upon heating, liberate corrosive acids, as well as those lime and magnesia salts which are precipitated as a result of heat and agitation, and should contain not over two grains of calcium carbonate, no magnesia salts except magnesium sulphate, or about half a grain of magnesium hydrate. Such a water will neither corrode nor scale condensers.

To illustrate what is accomplished in the purification of a water for condensing purposes, the following analyses are given. Analysis 5 shows a water from deep wells in Buffalo, N. Y., used on account of its temperature; this water caused considerable expense, due to scale and corrosion, and especially corrosion in ammonia condensers of the shell type. Analysis 6 shows the water after purification. A purifying system has been in use during the past four years and during that time no trouble from scale or corrosion has been experienced. Previously a new set of coils were necessary each year; with the present arrangement the life of the coils will be indefinite.

TABLE III.

Solids in Water. (Figured in Grains per U. S. Gal.)	Analysis 5. Well Water.	Analysis 6. Treated Water.
Volatile and Organic Matter	67.39	4.20
Silica	1.05	.93
Iron and Alumina Oxides	.23	trace
Calcium Carbonate	15.76	1.03
Calcium Sulphate	57.24	51.71
Calcium Chloride	14.38	56.56
Calcium Hydrate	.....	.57
Magnesium Chloride	36.29	.....
Magnesium Hydrate	.....	.48
Sodium Chloride	134.39	132.73
Total Solids	326.73	248.21
Free Carbonic Acid	1.34	none
Hydrogen Sulphide	saturated	trace
Temporary Hardness	15.76	1.03
Permanent Hardness	107.91	109.32

It will be noted that the treatment has practically removed the temporary hardness, the unstable magnesium salts, the hydrogen sulphide, and the free carbonic acid, thus giving a water alkaline in reaction and free from scaling or corroding substances. This water could not be softened and purified for boiler feed by any treatment other than distillation, on account of the presence of so large a quantity of sodium chloride.

DISTILLED WATER FOR CAN ICE.

The production of high-grade ice is dependent upon the purity of the distilled water. The boiler feed water has considerable to do with the purity of the distilled water. Preference is generally given to soft water, even if such a supply must be bought. Natural soft waters are usually surface waters which may carry large quantities of silt, mud, organic matter and other impurities which are volatile. When a feed water of this kind is used the volatile organic matter is driven off by the heat and is absorbed by the condensed steam. Its presence is evidenced by the odor and taste in the core of the ice. The odor and taste in the core, however, may not always be due to organic matter carried over with the steam, but to the lubricating oil.

Evaporation results in a continual concentration of the impurities introduced with the feed water, and if it were possible to generate absolutely dry steam, nothing but pure water, expressed by the formula H_2O, as steam, and the volatile matter, would enter the steam pipe. We all know that in practice absolutely dry steam is a rarity, steam carrying up to 3 per cent. moisture being classed as dry. Any moisture in steam leaving the boiler is water containing the same impurities in suspension and solution as the concentrated water in the boiler.

The amount of foreign matter carried out of the boilers with the steam is no small item. The following table, up to 3 per cent. moisture, may be interesting, and is based on a 500 horsepower boiler plant of a 150-ton ice-making plant evaporating 30 pounds of water per horsepower per hour, and an average of the total soluble and insoluble impurities in the concentrated boiler water taken at 300 grains per U. S. gallon, which is a fair average with ordinary water supplies:

TABLE IV.

Per Cent. Moisture in Steam Leaving Boilers.	Pounds of Concentrated Boiler Water Carried out of Boilers with Steam Per Hour.	Pounds of Impurities Carried out of Boilers with Steam Per Hour.
0.5	75	0.385
1.	150	0.77
2.	300	1.54
3.	450	2.31

The following analyses illustrate the effect of the impurities in water on the condensed steam. Analysis 7 is that of Lake Ontario water. Analysis 8 shows this water after concentration in the boiler. Analysis 9 is that of the condensed live steam.

TABLE V.

Solids in Water. (Figured in Grains per U. S. Gal.)	Analysis 7. Lake Water.	Analysis 8. Concentrated Boiler Water.	Analysis 9. Condensed Live Steam.
Volatile and Organic Matter	.15	7.40	.90
Silica	.25	.65	.75
Iron and Alumina Oxides	trace	trace	trace
Calcium Carbonate	5.00	3.77	1.25
Calcium Sulphate	....	10.13	.24
Calcium Nitrate	....	1.52	....
Magnesium Carbonate	.21	....	....
Magnesium Sulphate	1.20	.15	.18
Magnesium Chloride	....	.40	.13
Sodium Sulphate	.43	....	....
Sodium Chloride	1.15	30.00	.17
Total Solids	8.39	54.02	3.62
Suspended Matter	trace	1.60	.45
Free Carbonic Acid	.22	none	none
Incrusting Solids	6.66	....	....
Non-incrusting Solids	1.58	....	....

The use of boiler compounds often contaminates distilled water, as many of them contain acids, such as tannic and acetic, which are more or less volatile at high temperature and often have a corrosive action, so that they not only of themselves contaminate the distilled water, but may cause a discoloration of the ice by iron. Further, boiler compounds do not remove impurities, but increase the impurities in the boiler by the amount of compound introduced, increasing the soluble as well as the insoluble impurities, depending upon the action of the compound. This is illustrated by analyses 10, 11 and 12. Two boilers of the same type, using river water, operating for the same length of time under practically the same conditions, were used to test the efficiency of the compound, one boiler with and the other without compound.

TABLE VI.

Solids in Water. (Figured in Grains per U. S. Gal.)	Analysis 10. River Water.	Analysis 11. Concentrated Boiler Water, with Compound.*	Analysis 12. Concentrated Boiler Water, Without Compound.
Volatile and Organic Matter	.90	25.50	4.50
Silica	.45	2.20	.75
Iron and Alumina Oxides	trace	trace	trace
Calcium Carbonate	1.16	13.57	1.27
Calcium Sulphate	3.33	....	13.57
Calcium Chloride	....	....	18.11
Magnesium Carbonate	.50	.17	....
Magnesium Chloride	.43	....	....
Magnesium Hydrate	....	....	.68
Sodium Carbonate	....	12.65	....
Sodium Sulphate	....	41.39	....
Sodium Chloride	.05	24.06	22.16
Total Solids	6.82	119.54	61.04
Suspended Matter	.15	22.75	7.25
Free Carbonic Acid	.44	....	....
Incrusting Solids	5.87	....	....
Non-incrusting Solids	.05	....	....

* Sample after filtering has browaish yellow color.

Many of the impurities introduced into the distilled water do not affect the quality of the ice unless by a discoloration, as, for instance, when iron is present in feed water or introduced by the action of corrosive salts or acids on the boiler or steam piping. It is true that this iron should be removed from the water by the filters before passing into the fore cooler or cans, yet some of the iron salts are soluble and colorless, but after concentration in the core of the ice they are completely oxidized to the ferric hydrate by the air forced out of the water in freezing, and are indicated by a red color.

The extent of concentration of the impurities in the distilled water in the core of the ice is indicated by the following analyses. Analysis 13 is that of the boiler feed water. Analysis 14 is that of the concentrated boiler water after three weeks' operation, with regular blowing off. Analysis 15 is that of the distilled water, and analysis 16 is that of the melted butt.

TABLE VII.

Solids in Water. Figured in Grains per U. S. Gal.)	Analysis 13. City Water.	Analysis 14. Concentrated Boiler Water.	Analysis 15. Distilled Water From Fore Cooler.	Analysis 16. Melted Butt.
Volatile and Organic Matter	.70	23.20	.05	.25
Silica	.75	1.10	.35	.35
Iron and Alumina Oxides	.10	.25	trace	.05
Calcium Carbonate	7.50	4.25	.10	.50
Calcium Sulphate	.24	52.36	.17	....
Calcium Chloride	.....	7.69	....	....
Magnesium Carbonate	2.67	.....	.07	.21
Magnesium Sulphate	.55	1.39	.09	.19
Sodium Sulphate	.....	.....	trace	.41
Sodium Chloride	14.65	529.04	1.12	4.78
Total Solids	27.16	619.38	1.95	6.74
Suspended Matter	.25	111.80	....	*2.50
Free Carbonic Acid	.22	.....	.11	.11
Incrusting Solids	11.81	.....	....	....
Non-incrusting Solids	14.65	.....	....	....

* Suspended Matter in this analysis consists of organic matter, silica, and oxides of iron and alumina.

The use of softened and purified feed water in the boiler tends to increase the purity and improve the appearance of the ice: First, because in the process of softening the water all carbonic acid is removed except a small amount combined with lime as the carbonate. Second, because it so fixes the acid of those chlorides, sulphates and nitrates of lime, magnesia and iron present in the raw water that no decomposition by heat, to cause corrosion, can take place. Third, the organic impurities are reduced to negligible quantities and the inorganic salts of lime, magnesia and iron reduced to the limits of their solubility, and there is never more than a trace of iron. Fourth, the water fed into the boilers is perfectly clear. The sodium salts, of course, are not removed, as they cannot be precipitated by any chemical treatment.

The effect on the purity of the ice by the use of softened and purified water is illustrated by the following analyses. Analysis 17 is softened and purified boiler feed water, which is shown in its natural state in analysis 13. Analysis 18 shows concentrated boiler water after sixty days' operation, with regular blowing off. Analysis 19 is that of the distilled water from the fore cooler, and analysis 20 is that of the melted butt.

TABLE VIII.

Solids in Water. (Figured in Grains per U. S. Gal.)	Analysis 17. Treated Boiler Feed Water.	Analysis 18. Concentrated Boiler Water.	Analysis 19. Distilled Water From Fore Cooler.	Analysis 20. Melted Butt.
Volatile and Organic Matter	.25	7.30	.05	.15
Silica	.55	.55	.15	.35
Iron and Alumina Oxides	trace	trace	none	trace
Calcium Carbonate	1.25	.75	.25	.50
Magnesium Hydrate	.44	.09	.11	.21
Sodium Carbonate	.05	1.34	....	....
Sodium Sulphate	2.56	142.71	.21	.43
Sodium Chloride	15.50	725.40	.13	.23
Sodum Hydrate	.....	1.08	....	....
Total Solids	20.60	879.22	.90	1.87
Suspended Matter	.05	7.80	none	.05
Incrusting Solids	2.24	.....	....	....
Non-incrusting Solids	18.11	.....	....	....

WATER FOR PLATE ICE.

In plate ice plants the freezing forces suspended matter, air and other gases into the unfrozen water, making it necessary to frequently wash out the freezing compartment and refill with fresh water. This refilling with fresh, comparatively warm water results in a reduction of capacity or in more work for the refrigerating machine.

With the use of softened and purified water it is evident that there would be less concentration of objectionable impurities; therefore, fewer refillings would be necessary. I believe with most waters a decided reduction in the time of freezing would follow, as the water would be clear, free from carbonic acid and those soluble impurities which necessitate a slow rate of freezing to get clear ice. Further, the ice would be purer, for the organic impurities would, by softening and purifying, be reduced to negligible quantities.

In view of the expense occasioned by impurities in the water, the operator of an ice-making or refrigerating plant who does not carefully examine into the quality of the water supply, so as to eliminate scale, corrosion, etc., fails to obtain the highest refrigerating effect or the best quality of ice at least operating expense.

The elimination of scale, corrosion, etc., presents no greater difficulty, when proper methods are employed, than the pulling of ice or the regulating of room temperatures.

DISCUSSION.

President Block.—Mr. Greth made a statement in his paper which seems misleading. You were talking about an ammonia temperature of 210 degrees in the condenser. That only could apply to the first and second pipes of the condenser, I presume. I do not want the impression to go forth that the entire condenser may be supplied with ammonia gas at 210 degrees.

J. C. W. Greth.—I fully understand that. I was simply bringing out the fact that the water comes in contact with that 210 or 220-degree gas.

President Block.—I want to ask Mr. Greth whether the preparation which he has in mind, which he would propose for boiler feed water to be used in the ice-making plant, is a preparation to be introduced into the water in its cold state, or is the water treated hot?

J. C. W. Greth.—As a rule, it is treated cold. There are methods of treating it hot, but these do not give the best results, because the heating apparatus has to be cleaned from time to time, inasmuch as there is partial precipitation in the heating apparatus, while if you treat the water cold before it goes into any of the apparatus you can prevent any deposit from the time it leaves the water-treating plant until it has served its purpose.

President Block.—It has been definitely ascertained, has it, Mr. Greth, at what temperature the precipitation would begin?

J. C. W. Greth.—Any rise in temperature starts precipitation of the temporary hardness. Take a well water at 56 degrees and heat that water two or three degrees and precipitation begins. On the other hand, taking water at 56 degrees, agitation alone is sometimes sufficient to start precipitation without heating.

President Block.—Does the precipitation take place more rapidly in water exposed to the atmosphere than it would in water enclosed in pipes or vessels?

J. C. W. Greth.—That depends a great deal on the character of the water. Some waters will precipitate more rapidly or readily under the slight pressure which they would be under in a closed vessel than they will when exposed to the atmosphere. On the other hand, water exposed to the atmosphere, as on an atmospheric condenser, will sometimes precipitate more rapidly and readily and at a lower temperature, as the gases can leave the water more freely.

President Block.—Is all the CO_2 neutralized in this process of purification which you have in mind?

J. C. W. Greth.—All of it has to be removed in order to effect

purification, and not only the free carbonic acid, but all the half-bound carbonic acid must be removed in order to reduce the carbonates of lime, magnesia and iron to the lowest point. You can remove all the carbonates of iron and magnesia and leave a small amount of lime in the form of the normal carbonate.

President Block.—At what temperature do the solids begin to precipitate?

J. C. W. Greth.—In distilled water, calcium sulphate begins to precipitate at 300 degrees Fahr.; but the presence of other solids in the water tends to increase the solubility of calcium sulphate, so that you will find in blow-off water from boilers, where the temperature is as high as 360 degrees or 375 degrees, sometimes as high as 30 grains per gallon of calcium sulphate in solution. The precipitation of calcium sulphate in a boiler is rather interesting. As the water concentrates in the boiler it gradually accumulates until, we will say for a particular water, the limit of solubility—25 grains—is reached. At that point, due to a sudden demand for steam or for blowing off the boiler, or owing to any change in the conditions of operation, the calcium sulphate will suddenly precipitate and carry down with it a great deal of suspended matter, carbonates and other substances, and deposit it in a layer. As a rule, the calcium sulphate scales are laminated; that is one explanation of their being present in layers. The calcium sulphate will not all be precipitated, but it may drop from, say, 25 grains, if that is its solubility in the boiled water, down to 10 or 12 grains. It must crystallize suddenly to carry down with it the other stuff, on which it acts as a cement.

President Block.—Mr. Smith, have you in mind that there are any other salts in solution in this distilled water? Were any found in the samples you have analyzed?

Kenneth G. Smith.—I have in mind only one instance where there had been trouble with the ice being discolored, and was told that that discoloration had come from iron, according to the analysis that had been made.

President Block.—No carbonates nor sulphates?

Kenneth G. Smith.—None that were mentioned.

Peter Neff.—Is the sulphate more apt to remain behind than the other salts?

J. C. W. Greth.—It does not make much difference in what form is the impurity; the sulphate is in solution or suspension in the water, and the moisture carried out of the water from the boiler carries over with it whatever happens to be in that particular water.

The sulphate is more apt to remain behind, because when that once is thrown out of solution it is generally as a hard scale.

John E. Starr.—There is a growing tendency in boiler practice to use superheated steam. I would like to ask Mr. Greth's opinion as to the effect of superheated steam upon the solids. He has stated that, on the average, perhaps three per cent. of water is carried from the ordinary boiler. If this steam, containing two or three per cent. of water, is afterward superheated, would the result be in dropping out the solids or scale in the superheater, or what would be the probable effect?

J. C. W. Greth.—I had occasion to go into that matter very thoroughly during the latter part of 1907 and early in 1908, and I covered it pretty thoroughly in an article in *Power and The Engineer* in July, 1908. The moisture in the steam, of course, carries the impurities into the superheater, the water is immediately vaporized, and any impurity in the water will deposit or be mechanically carried along into the steam pipe. The result is that the superheaters in many plants have become entirely plugged up. In others the deposits have formed on the pilot valves and vanes of the steam turbine; also, in the traps and auxiliaries in connection with the steam piping. In some cases it has almost put the superheater out of use, on account of the enormous deposits as the result of the continuous carrying of moisture out of the boiler into the superheater. And that is further increased by the fact that, in starting up the boiler, the superheater is flooded, and the evaporation taking place brings about a concentration; and the superheater not being carefully drained, the result is that the superheater starts out with a heavy coating of scale. Much of the cutting action which is attributed to the superheated steam is more apt to be due to the sand-blast action of the finely divided crystals precipitated and carried at high velocity with the steam.

No. 67.

WHAT IS THE MEANING OF THE TERM EFFICIENCY?

By Peter Neff, Canton, Ohio.

(Member of the Society)

The past few years have shown a wonderful awakening of interest in the consideration of refrigerating apparatus, but there has been manifested a certain recklessness in the use of the terms to imply certain relationships, and no one word has been made to cover a wider range than the term "efficiency."

This word when used by trained observers has usually been modified so as to explain what ratio was intended to be covered, but those of us who have been in the business for a long time have noticed uses of this term by salesmen and others when its meaning was obscure, and possibly intentionally so in many cases. It would, therefore, be eminently proper, it would seem to me, if this organization should put its stamp of approval or disapproval on certain expressions which are coming into use more and more, for we have now reached that stage when scientific problems involved in mechanical refrigeration must be given careful consideration and terms employed must have a uniformity of meaning if results are to be compared. The ambiguity of the term has been recognized by members of this Society before.

No doubt many in using the term have had clearly in mind the relationship intended and yet have failed to qualify it so as to make the relationship clear to others. Again, others seem to have no idea of the meaning, or at least a very distorted one. As an example of the latter, a salesman made out a contract proposal and specified his machine as 98 per cent. efficient. Another salesman, seeing this, promptly put his machine at 100 per cent., and when asked what he meant, said his machine would do the work, therefore was 100 per cent. efficient.

Here are two expressions used by the same party to represent precisely the same ratio, "Actual Volumetric Efficiency," "Actual Efficiency." The first would appear to mean something definite, while the latter appears like advertising. Again, he uses simply "volumetric efficiency" for a different relationship from the forego-

ing. One states that "volumetric efficiency is the ratio of the actual volume of vapor drawn from the suction pipe to the compressor displacement for the same time," while another defines it simply "as the percentage of displacement."

During a recent test the professor in charge was asked to indicate in his report the "volumetric efficiency." He was furnished with all data available relating to the use of this term by others. In his report he stated as follows:

> An attempt was made to present the volumetric efficiency under definite names, but a brief study of this subject reveals the fact that there seems to be no definite agreement as to the name which shall be used to specify any given volumetric efficiency. What one man calls "mechanical volumetric efficiency" another calls "real." There seems to be considerable confusion in the use of the terms real, mechanical, theoretical, apparent, etc.

He gave four distinct ratios for volumetric efficiency of the apparatus in question, and these varied from approximately 75 to 90.

Dr. Siebel, in his Compend of Mechanical Refrigeration, says:

> The term efficiency has a variety of meanings, and the one specifically intended should be expressed clearly in each case. Generally efficiency is expressed by the number of units of heat removed from the refrigerating coils or refrigerator for every thermal unit of work done by the compressor. * * * This may be called "actual" efficiency, as it varies not only with the machine but also and most positively so with the local conditions under which it works. * * It offers no criterion as to the lost work done by the compressor; *i. e.*, it is not an expression for the degree of perfection of the compressor.
>
> In order to obtain a comparison for this quality, we must, according to Linde, compare the actual efficiency of the plant with the maximum theoretical efficiency of the plant when working under the same conditions.

Another states: "The expression for efficiency as a compressor may be written thus:

$$\text{Efficiency} = \frac{\text{Initial Quantity of Heat}}{\text{Work Performed}}$$

He then states in explanation of this expression "that the efficiency of a refrigerating apparatus is increased when the initial temperature is raised," etc. Here he uses the term "apparatus," manifestly a broader term than compressor, and might mean the whole machine, including its motive power.

Another states: "In a refrigerating plant high efficiency means passing the maximum weight of gas through the cylinder of the compressor with a given expenditure of power."

Further on the same party states: "There is the efficiency of the compressors as a complete machine, or the ratio which the indicated horsepower of the steam cylinder and the compressor bear to one another."

Another, in speaking of efficiency in a compressor, states the following: "The principal qualities to be sought for in a compressor, in order to insure the maximum amount of efficiency, are as complete a discharge from the compressor cylinder of the gas during the compression as is practically feasible, and the removal during the compression of the greatest possible amount of heat from the gas."

Still another gives the following general expression for the efficiency of a refrigerating machine: "Energy obtained divided by energy expended."

Examples could be multiplied to show the variation of language regarding efficiency.

A good deal has been said in a recent discussion as to the value of indicator cards in determining the efficiency, and just here I want to say a word in regard to the value of indicator cards in determining anything in regard to the compressor.

It is true that the mere appearance of the indicator card tells nothing, and until you have laid in the adiabatic and isothermal lines you are not in a position to interpret any card correctly. But I want to add that the indicator card that does not have traced upon it, while on the indicator, the line of suction pressure cannot ordinarily be interpreted correctly.

My attention was particularly called to this in connection with a large amount of indicating which was being done at one time and on which several standard and supposedly correct indicators were used. The results from these indicator cards varied. A connection was made to the indicator cock so that immediately upon closing it off from the compressor this connection could be opened and the pressure in the suction pipe just before it entered the compressor brought under the piston of the indicator. The result was rather surprising. The filling line of that card showed above the suction pressure line, manifestly an impossible condition. This did not occur with one indicator, but with several, and with certain makes of indicators it was impossible to get a true reading. In other words, suppose the compressor was not filling to suction pressure; this error of the indicator, if scaled up, made it appear that the compressor *was* filling. To indicate the compressor properly requires a first-class indicator, and this must be in first-class condition; and I would not give any value to an indicator card that did not show this suction pressure line.

The use of thermometers on both suction and discharge of the compressor is a necessity in the study of compressor performance.

In steam engine practice several efficiencies are recognized. In discussions in regard to engines, the efficiency is usually specified so that it is self-explanatory.

In speaking of engine performance, it is stated: "In the early days of engine testing it was usual to express the performance of the engine in terms of the number of pounds of coal used per indicated horsepower per hour, which was all right if the performance of the whole plant was desired; but as a scientific measure of the performance of the engine itself it was valueless, because it included also the performance of the boilers."

A committee of the Institution of Civil Engineers, London, considered this question and issued a report, of which the following are some of the recommendations:

1. That thermal efficiency as applied to any heat engine should mean the ratio between the heat utilized as work on the piston by that engine and the heat supplied to it.
2. That the heat utilized be obtained by measuring the indicator diagrams in the usual way.

They then go on to show what degree of temperature of the steam, both live and exhaust, should be taken, and gave the standard method adopted, and continue:

That the ratio between the thermal efficiency of an actual engine and the thermal efficiency of the corresponding standard steam engine of comparison be called the "Efficiency ratio."

It is probable that in future steam-engine performance will be expressed in terms of thermal units per minute per I. H. P.

The theory of efficiency of ideal engines, applying steam or other vapor as the working fluid, is simple and exact, but the results obtained in this case differ usually very widely from those practically reached in the real engine of which it is the representative.

The author then goes on to show that there is "an efficiency of the machine," of "steam of machine," of "engine friction," of "engine and jacket," etc.; that "heat engines of whatever class, type or form simply convert thermal energy into useful dynamic energy, and their efficiency is, therefore, measured by the ratio of the amount of energy thus rendered available to the quantity of the energy originally supplied for transformation," and compressors simply reverse this order.

Then there is the efficiency of the compressor and combined motive power. You can have a good compressor and a poor engine, or a compressor not so good and a better engine, and the combined results, or the value the purchaser is buying, may be greater in the latter case than in the former. The sooner this Society gets down to some basis which will make it plain what is meant by efficiency

of refrigerating apparatus and define the several different efficiencies, the better for all.

There are so many able refrigerating engineers working continually on this subject that it would take but a short time for them to agree on certain efficiencies and give them their proper name, and thus render to the trade in general, and to the refrigerating engineers as a class, assistance which those of us who are called upon continually to figure would find a great boon.

At the present time I have no definite suggestions to offer as to what terms should be used, but I feel that the refrigerating apparatus as a whole should have its efficiency rating, as well as the compressor and motive power, and that the compressors alone should have a volumetric efficiency, the method of determining which to be clearly set forth. It will be necessary to have reduction tables carefully worked out for superheated gas and other conditions, so that the practical operation of a compressor can be reduced to the standard adopted. And I earnestly hope that these matters may be taken up by this Society in a thoroughly scientific manner, not hastily; and that after mature deliberation, with practical examples of their working, recommendations be made, not only for standards of efficiency, but for other ambiguous expressions—recommendations which will command the respect of the world and assist in placing this branch of engineering upon the high plane where it belongs.

DISCUSSION.

Charles E. Lucke.—Mr. Neff has made the statement in his paper, "It is true that the mere appearance of the indicator card tells nothing, and until you have laid in the adiabatic and isothermal lines you are not in a position to interpret any card correctly."

It is a fact that very few refrigerating men, or very few whom I have met, know how to do that, especially with wet vapors. It is also a fact that wet vapors are more commonly in use than dry vapors, whether we know of the wetness or not.

I also note a statement, lower down, to the effect that the filling line of the card could not rise above the suction-pressure line. I think that is true for the greater part of the line, but toward the end I think it is not always true. There are compressors handling air in existence today that have a so-called volumetric efficiency exceeding one hundred per cent. There is nothing phenomenal or queer about it. Corliss inlet-valve compressors will show a rise of pressure toward the end of the suction line to considerably over

atmospheric pressure by holding the inlet valve open just the right length of time, which will allow the inrush of the incoming air to build up the pressure. If, then, the compression line, when it has really been formed, be produced backward toward the atmosphere, it will intersect the atmospheric line at a distance from the end of the stroke intersection greater than the difference between the re-expansion line and the other end of the stroke, thus causing a so-called higher volumetric efficiency than 100 per cent.

I note also, in Mr. Neff's plea for standardization, this statement, assuming a standard to have been established: "It will be necessary to have reduction tables carefully worked out for superheated gas and other conditions, so that the practical operation of a compressor can be reduced to the standard adopted."

Now it is proper that we recognize that such tables as we have, giving the properties of vapors which would be the basis of such reduction tables, are themselves in error; that, therefore, we cannot make any reduction tables until we first establish a correct basis for our standard saturation tables.

Peter Neff.—I am very glad to hear that. Those values should be worked out, and I have so stated. In figuring the horsepower per ton of refrigeration, I have found difficulty in getting at a value for *N*, etc.

In regard to indicator cards, what you say is true of certain air compressors, but could not be in the ammonia compressors referred to, in which the filling line of the card was above the suction-pressure line drawn by the indicator and ran parallel with it, and was not the condition you mention. My point was to show that the ordinary indicator is very apt to be irregular, and to give an easy way of showing up one form of irregularity.

President Block.—In other words, we must never accept the capacity of a refrigerating machine if it is guaranteed by the indicator card?

Peter Neff.—No.

No. 68.

THE ICE FACTORY OF THE FUTURE.

By Victor H. Becker, Chicago, Ill.

(*Member of the Society*)

To think of the "Ice Factory of the Future" involves an appeal to the imagination, that faculty of which John Tyndall said: "It is the power by which we picture to ourselves effects beyond the range of our known senses." Without imagination we might have *critical* power, but not creative power in science. I have always been very fond of this particular faculty, although I generally hesitate much in putting the effects of its exercise into lines as short and devious as are commonly used in forming letters and words, and I trust you may find something to interest, instruct or possibly even to amuse in this digression from one of my habits.

An ice factory is now an institution, the details and characteristics with which most of us are fairly familiar. Some of us even have recollections more or less vivid concerning the processes through which it has passed during its short career in arriving at even the present imperfect state of its growth. Like all great industrial betterments, the development, while hesitating and at times even retrogressive, has, nevertheless, tended steadily forward. No mean degree or quality of ingenuity has been displayed by many men in overcoming apparently insurmountable difficulties. Likely there were stages of which no visible record has been left on the structure itself that involved a far greater tax on the ingenuity of their authors than was required in the production of the more permanent ones, but which nevertheless were of great temporary value in tiding over critical periods or in suggesting more practical means of attaining the objects sought.

This reflection is suggested by the vogue the distilled water ice plant has found and appears still to maintain in spite of the excessive fuel and maintenance cost involved in its operation. My own mind never has accepted as a logical deduction the declaration that to insure pure ice it must be made of distilled water, and, therefore, in cans; nor am I now ready to admit that it is good engineering practice to heat water to or above its boiling point, much less to con-

vert it into high-tension steam very much in excess of the requirements of the modern power plant employed in order that the ice that plant is capable of producing may be transparent, and, therefore, pure and salable.

I do not think the statement that perfectly transparent ice is practically pure ice, irrespective of how it was made, should provoke any adverse criticism here. I do believe that a block of crystal clear ice affords a good optical analysis of the water of which it is composed, irrespective of any process of manipulation that water may have undergone before it was congealed.

I do not assert that to congeal water into ice necessarily purifies it, but I believe it is generally conceded that practically all of the impurities in a block of otherwise clear ice, whether natural or manufactured, are segregated in any opaque strata or seam it may contain. On the other hand, it does not follow that an opaque stratum in a block of ice necessarily contains impurities; this condition may be caused by confined air of perfect purity or by other harmless gases or matter. Such rapidity of freezing that the planes of the crystals composing the ice are out of contact with each other, and, therefore, refract light, has the effect of giving the ice a milky or cloudy appearance, which, while it is an undesirable condition, is not necessarily a bad one.

When Professor Twining made his original experiments in the production of "Artificial Ice" in the middle of the last century, he filled his receptacles with the purest water at his command—well water; he called it "Pump water." By slow freezing he expelled considerable of the air from this and made fairly clear ice; but when his compressor worked exceptionally well and he was enabled, consequently, to freeze his water more rapidly, the ice was less transparent, because more air was confined. If this air was clean the ice was not, therefore, less pure.

When Carre began making ice in narrow tin cans filled with natural water and immersed in a bath of refrigerated diluted glycerine the slabs of ice were quite opaque. Boiling the water did not improve the ice much, as it was introduced into the cans by pouring it through the air.

At this stage in its development a doubtful step was taken, from the effects of which the ice factory has not yet entirely recovered. *To make clear ice the water was distilled.* While the immediate effect of this step was larger cans and successful competition with natural ice in our Southern cities, it nevertheless was an unfortunate step.

At first the distilling apparatus used was imperfect, almost as bad as some of the present day; the necessity of keeping clean boilers was not appreciated, nor were charcoal filters or deodorizers used. It is not to be wondered at that persons using it in drinking water complained of the well-known objectionable taste in the ice, which the competitor promptly magnified into "ammonia or other chemicals." Not to be outdone in ingenuity in his trade-getting, the manufacturer informed the trade that his ice was not as likely to contain ammonia as was food prepared on a gas stove to be contaminated with the odor of gas.

When it was at all possible great virtue was claimed for the manufactured ice because it was made of "aqua pura," and soon the word "hygienic" was applied to can ice, because it was made of water distilled at a very high temperature before being frozen at a very low one, the intermediate stages being carefully ignored.

So it came about that distilled water was used to ensure transparent ice. The idea of its supposed "hygienic" properties came after as a sequence, or as a defensive measure in the sales department. The great consideration was to make ice which would be at least as clear, and, therefore, as durable, as that offered by dealers in the product of Nature. As it had been demonstrated that blocks of uniform shape, size and transparency could not be frozen fast enough in cans for economy without distilling the water, distilled water ice held its own and even forged to the front, despite all the difficulties attending its production.

Other methods of making clear ice in blocks of practically uniform size and shape were developed as the number of small ice factories increased in the South; but because plants of only small capacities were required, and as the can system was best adapted for such plants, these did not receive the attention their merits entitled them to.

The system of making clear ice of undistilled water in cans and on submerged plates by blowing air through it was the subject of careful experiment in this country early in the history of the business; but the issue of a broad U. S. patent, afterwards invalidated, to one T. B. E. Turrettini, of Geneva, Switzerland, on October 23, 1877, covering broadly this principle, served as an effectual damper to its fuller development until after the distilled water plant had become too well established to be readily superseded by any other system of making can ice.

After the expiration of the Turrettini patent the system was again taken up, but the distilled water plants were too well estab-

lished. It is now used principally in plate and block ice plants and in not many instances to make raw water ice in cans.

Those familiar with this remarkable patent only have been men whose attention was expressly called to it. This document is indexed in the Patent Office as a "Process of Treating Water," and few were likely to seek information concerning ice making under such a title. I will quote the pertinent specifications of this patent, which was filed on July 20, 1877, and issued October 23, 1877, the number being 196,316:

EXTRACTS FROM TURRETTINI PATENT SPECIFCATIONS

The object of my invention is to secure the production, in ice-making machines, of ice which will be clear and free from the air bubbles which are generally to be found in artificially-made ice; and to this end the invention consists in passing a current of air or suitable gas through the water to be frozen, for the purpose of agitating the same and releasing and driving out the contained air.

I am aware that various attempts have been made to secure this result by agitating the water in the molds, during or immediately previous to its congelation, by mechanical agitators and by causing a circulation, and a patent has also been recently granted to me in France for subjecting the water to a vacuum while being agitated; but said methods are all objectionable for different reasons, among which is the serious one that when used on a large scale they necessitate the use of complicated and expensive machinery.

My present plan possesses the advantage of extreme cheapness and simplicity, combined with that of an efficiency exceeding that of either of the other plans.

The construction of the ice machine proper, and of the apparatus for carrying out my invention therein, may be varied at will, and have no bearing on my present invention.

Any apparatus may be used in carrying out my method or process which will secure the passage of air or gas through the water and permit its escape therefrom, a simple arrangement being to connect, with a blowing engine, pipes which extend down into the molds of the ice machine nearly to their lower ends. The air escaping from the pipes ascends rapidly through the water in the form of large bubbles, having great buoyancy and a strong upward tendency, and which escape in quick succession at the surface. The bubbles encounter in their upward course the small bubbles or globules of air held in suspension in the water or adhering to the walls of the mold, and the result is that the small bubbles coalesce with the large and both ascend and escape together, the air from the pump thus taking up and conveying out the air held in suspension or solution by the water. The inflowing air also serves to violently agitate the water in the mold, and in that way serves to release a portion of the contained air, which will rapidly ascend and escape as soon as the water is set in motion and the equili brium destroyed.

Having thus described my invention, what I claim is—

1. The method of securing the production of clear ice in ice machines, by passing a current of air or gas through the water to be frozen, substantially as described.

2. The method of treating water to produce clear ice, consisting in passing air or gas through the same while being subjected to refrigeration.

Surely this language covered the ground broadly enough; but, unfortunately for the validity of the patent, all of this had been done in this country more than two years before the applicant's con-

ception of it. But the business of making ice was at so precarious a stage at this time that the prospect of even threatened litigation looked ominous to those interested in it.

Because of the unfriendly attitude of the large natural ice dealers, the business of making and selling "machine ice," as it was derisively called many years, remained in the hands of small but enterprising investors, and these by sheer force of growing numbers have in recent years won, first, attention, and then recognition as dangerous competitors.

It seems almost paradoxical to one who participated in the hard fight to force the installation of ice factories in the early days in the Southern States, where natural ice was obtained only at great expense, and then with doubtful regularity, and by one who often was turned from the desks of natural ice dealers engaged in business as far south as Pittsburgh, Cincinnati, and even Louisville, with the assurance that they entertained no fear of the encroachment of the machines in their territory, to enjoy, as I do, the knowledge that the product of the ice factory of the present is rapidly supplanting natural ice, even in our most northerly States. The appearance of route wagons, carrying from five to ten tons of manufactured ice in three hundred, four hundred, yes, six and eight hundred-pound blocks, on the streets of Boston, Detroit, Chicago, St. Louis, Omaha, Denver and Portland carries almost a personal degree of satisfaction.

Manufactured ice is now actually being sold at better prices than natural ice in Canada and British Columbia. It is almost the sole reliance of the people of the Southern States. But are we doing our duty; are we following up our advantage as we should? I mean as engineers. No doubt the commercial end of the business is being well taken care of, but are the engineers keeping up and "toting fair" with the art? I do not think so, unless it is conceded that to satisfy a customer necessarily implies good engineering, or that to maintain a condition of freedom from pain or care in a patient by administering opiates is uniformly good medical practice. Is it not true that too little thought is being given to building the ice factory of the future, and that much of the work done is of a temporary quality and much too cheap?

In the conflict for positions of advantage in the market, which has been waged with fluctuating success during recent years between the products of the factories and of the ponds, all conceivable devices of commercial warfare have been resorted to. Each of these has likely had the success its merits won for it.

More lately chemists and bacteriologists attached to municipal

departments of health have, after proper investigation, issued reports of their findings more or less favorable to manufactured ice. These, in a number of instances, have resulted in legislative enactments to control or even to prohibit the sale of ice harvested from objectionable bodies of water because of the danger of contagion. But now the bacteriologist has invaded our ice tanks and finds, as did Dr. Hill, in Boston, several years ago, that "artificial ice contains—especially in the center and bottom of the cake—about as many 'dangerous bacilli' as the average in natural ice." "The outside of the cake," he says, "is likely to contain very few." This refers to distilled water ice made in cans.

Last summer I participated in an investigation of an ice plant in an Eastern city for the purpose of checking very discrediting reports, then being published in the standard medical journals, of bacteriological examinations of distilled water ice then being supplied by plants in Washington, D. C., and in other localities. The examinations were made under the direction of an expert of large experience and without prejudice. We found the filtered water supply of the boilers and the condensed steam at all of the principal stages of its passage to the ice cans practically free of bacteria, but the middle and bottom of each cake contained several varieties of polluting organisms in forbidding numbers, which readily were traced by cultures of matter scraped from the under surface of the covers and the moist sides of the wooden supporting rails over the coils. I have no doubt but that the same condition may be found in any ice tank after it has been in use a year or more. Damp wood appears to afford a favorable medium for the rapid multiplication of harmful organisms, even though it is refrigerated in an ice tank.

Unagitated water, more especially unaërated distilled water, once it is infected with living bacteria, seems, because of its neutral quality, to afford just about what is needed for their rapid propagation. It may be true, as I have heard it stated, that any microbe that can stand boiling and freezing deserves to live; but I do not believe they should be knowingly sold to the general public for profit.

Those best informed on this subject are agreed that distilled waters, like many other sterilized and pasteurized liquids, are hygienic only so long as they are excluded from contact with impure air or unclean surfaces. Being neutral, distilled water has great affinity or hunger for other matter. In fact, because it is a more willing solvent is one reason why it is preferred for chemical solutions. Its well-known corroding influence on metal aptly illustrates these characteristics. When uncharged with air or other suitable

gas it is not desirable for consumption by growing children or delicate persons, because of its tendency to neutralize the natural salt of the body.

Doubtless I have made it plain that the ice plant of the future will not be a distilled water plant, except possibly for the installations designed for small output or for special uses. Most large plants in the future—and I hope to see them built for very large capacities—should be arranged to make ice of filtered and aereated water or on agitated or washed vertical freezing surfaces, so arranged that extravagant outlay for the construction, insulation and maintenance of great tanks will be avoided. If cans are to continue in use, I apprehend that they will be filled with raw water, to be agitated by inducing air to rise through it, or they may be made without bottoms and so arranged that atomized water can circulate through them.

I have taken the necessary steps to secure a method of making raw water ice, which is best described as follows:

By forcing raw water, with or without the admixture of added air, through suitably located atomizing devices, I forcibly dissolve more water in the air, which is in contact with a system of artificially refrigerated freezing surfaces, than the low temperature of such surfaces will permit such air to continue to hold in solution, that they may condense such atomized water, out of such air, to satisfy their freezing capacity. Enough in excess of this amount will also be condensed to prevent such surfaces from freezing dry, the object being to form clear ice of water containing air, gas or solid matter without distilling it, but by atomizing it in such quantity proportional to the congealing capacity of the freezing surfaces as will cause it to constantly wash the forming ice surfaces and thereby prevent the adherence of air bubbles or organic impurities thereon. When it is of the desired thickness, or when the sheets of ice formed on two adjacent freezing surfaces have met, it may be removed by any known means of thawing or cutting into blocks of any desired form or size. The water may be mechanically cooled or filtered before being atomized. Such water as has not adhered to the freezing surfaces, but has served to wash them, is drawn from a suitable collecting space below by the pump which supplies the atomizers.

In adapting this method of making clear ice to existing plate plants I will simply keep the tanks practically free of solid water and operate the atomizers just under the covers. By adding an additional taper plate midway in the space between the existing plates—utilizing the space before occupied by the left-over water—

I will double the freezing surface in each tank and much more than double the amount of ice the tank is capable of turning out, besides maintaining the entire ice-forming system clean and pure.

Should it be deemed preferable to form ice in cells or molds, I will form it on horizontal pipe coils arranged to cross each other at right angles, or by connecting them at their intersections so as to form vertical square or oblong cells proportioned to form ice six, eight, ten or eleven inches thick, as may be required, leaving an unfrozen center to which the ice may be cut into convenient blocks by any known means.

In this arrangement the ice may be lifted from the cells, or it may be lowered into a space arranged below them for that purpose. This space may also be arranged for storage and may contain conveyors.

I may say, among other things I know in favor of this method of making ice, that I have made absolutely transparent 12-inch ice on a bare direct expansion plate in seventy hours by sprinkling the water upon it. It is well known that the force exerted against the forming ice surface in sprinkling water directly upon it operates to retard the freezing process, whereas to condense the water from the air is an operation so natural and so without violence that the full ice accumulating capacity of the surfaces will be realized. The amount of water to be condensed on the freezing surfaces, in excess of their congealing capacity, to insure the transparency of the ice can be determined by handy adjustment of the atomizers. If desired, the water may be forecooled to any desired temperature, even to below its freezing point, while it is in motion, and under pressure before reaching the atomizers. This latter operation is pregnant with experimental possibilities of some value.

It doubtless has been observed that my ideas about the preparation of water for freezing it into pure ice in the ice plant of the future run in the right direction and do not involve imparting large amounts of additional and highly detrimental heat to it. I propose to begin to make clear ice at the time I start to handle water for that specific purpose, instead of mixing it and exposing it to unnecessary contamination and heat with the water used in a power plant at high temperatures and for other purposes.

THE COMPRESSION SIDE OF THE ICE PLANT OF THE FUTURE.

It seems to have been determined that ammonia is at present the most practical refrigerant for use in the larger installations,

although there still are lively contentions as to whether it is most advantageously used in its anhydrous state or when it is dissolved in water. Probably both the compression and the absorption systems will survive in their most favored fields. Carbonic acid gas does not seem to be falling behind in favor for the smaller plants, necessarily installed in confined places and for uses where they are especially favored by other local conditions.

The single-acting, vertical, water-jacketed compressor, having a reciprocating piston, containing a suction valve of large area which is swept in its open position through the practically confined suction gas, and which seats promptly when the motion of the piston is arrested at the end of the downstroke, it seems to me must remain the most efficient compressor of the piston type.

The evaporator best adapted to supply such a compressor with gas under a pressure somewhat higher than that due to its temperature, whether this end be attained by filling the coils with liquid previously refrigerated in a so-called accumulator by its own partial evaporation, or in a separate cooler, by the operation of an auxiliary compressor operated with a low back pressure, will doubtless meet with most general adoption, because it will occupy the minimum amount of space, entail the employment of the minimum amount of surface and the minimum number of fittings and joints to be installed and maintained.

Possibly a turbine compressor operated at a high rate of rotation and mounted on the same shaft with a highly economical turbine engine, a gas or other high-speed, internal-combustion engine, or with an electric motor, may be realized in the compression ice machine of the near future. Such a compressor, if it is to come, will probably come as an attendant of the perfected turbine engine. Air compressors of this design are already in use. The growing disposition to utilize natural water powers also points in the direction I have indicated.

Concerning the absorption machine, it seems to me that quite as great possibilities are within its reach for future development as the compression machine has before it. I have also devised means which hold out strong hopes in this field, which are best described as follows:

I propose to add to any existing absorption refrigerating plant a "booster" pump, connected to aspire the gas from the evaporator and to discharge it into the absorber at a pressure enough higher than is normal for the gas and the poor liquor at the evaporating temperature, so that the exhaust steam of the engine driving the

booster and the rich liquor pumps will supply all the additional heat needed in the generator to create the pressure necessary for liquefying the gas delivered in the condenser. Thus the booster and the rich liquor pump are compounded with the generator and its coil at their ammonia and their steam ends, respectively. The water resulting from the condensation of the steam in the generator coil may be returned to the boiler as feed water.

The booster may be an inexpensive rotary or turbine pump, as it will discharge against a relatively low pressure only, or an injector may be employed to boost the pressure of the gas issuing from the evaporator to any desired pressure in the absorber below the pressure of the poor liquor which is forecooled—under the pressure it attained in the generator—for use as the absorbing and pressure medium.

Reflection on the subject will reveal that, by the operation of this arrangement of parts, the equivalent of a reduction of the temperature of the cooling water used on the poor liquor cooler and the absorber will be attained; and as it is well known that the efficiency of an absorption plant rapidly falls as the temperature of the water used on these parts is raised, it is readily seen that this addition will greatly benefit any absorption plant, and that those plants of this type which have been installed where only high-temperature cooling water is available will be lifted out of the class of failures by its use.

In one of my articles published in ICE AND REFRIGERATION last year I made reference to some experiments with a small plant in 1876 or 1877 when I applied a special steel "Sellers" injector to absorb and convey the ammonia gas directly from the evaporator coils to the generator by the previously cooled poor liquor taken from the generator. I am now convinced that those experiments disappointed me principally because the injector exhausted the gas from the freezing coils, they not being of sufficient capacity to supply it with gas in the proper proportion to the poor liquor arbitrarily supplied to it.

I, therefore, conclude that I may yet succeed in this application of the injector, in which I will require very little additional heat in the generator to create sufficient pressure for liquefying the ammonia in the condenser.

If I have succeeded in pointing only in the direction where the ice plant of the future may be found as compensation for my unfavorable criticisms of the ice plant of the present, I cannot with justice be termed a "kicker," more especially as the motives behind my criticisms are not unfriendly.

DISCUSSION.

President Block.—Mr. Becker, what do you mean by saying, "an evaporator best adapted to supply such a compressor with gas under a pressure somewhat higher than that due its temperature"?

Victor H. Becker.—I meant to express the hope that the gas resulting from the evaporation of the precooled liquid would be used as a forecooler of the water to be frozen before the gas went to the compressor.

President Block.—That is nothing new, is it?

Victor H. Becker.—No.

President Block.—But you say: "Under a pressure somewhat higher."

Victor H. Becker.—Not lower?

President Block.—But the gas can only be at that pressure which corresponds to its temperature.

Victor H. Becker.—Theoretically, but actually it will be higher.

President Block.—If you superheat it?

Victor H. Becker.—You do superheat it the minute you take it away, unless the pipe conveying it is perfectly insulated.

President Block.—But as long as the gas is still in connection with the evaporator it would be exactly under the same pressure?

Victor H. Becker.—As long as it is in contact with the vaporizing liquid, but when it has traveled a number of feet away from there in the pipe it is likely to be higher.

President Block.—It may be slightly lower, owing to the frictional head?

Victor H. Becker.—But it is more likely to be higher.

President Block.—Then there is another statement you make. You say: "I propose to add to any existing absorption refrigerating plant a 'booster' pump, connected to aspire the gas from the evaporator and to discharge it into the absorber at a pressure enough higher than is normal for the gas and the poor liquor at the evaporating temperature, so that the exhaust steam of the engine driving the booster and the rich-liquor pumps will supply all the additional heat needed in the generator to create the pressure necessary for liquefying the gas delivered in the condensers."

In view of the fact that the efficiency of the absorption machine is but slightly decreased by lowering the temperature in the evaporator, and it all depends upon the surface of the absorber, why should any additional machinery be used to accomplish that which

can be accomplished by simply adding a few more feet of surface to the absorber?

Victor H. Becker.—To render existing absorption plants more efficient by raising the pressure of the ammoniacal solution in their absorbers; in other words, to raise the pressure under which the poor liquor is absorbing ammonia without raising the pressure under which that ammonia is evaporating. This will increase the capacity of the absorber, and will result also in increased efficiency for the aqua pump and of the still. If the booster is of sufficient capacity to lower also the evaporating pressure, an increase in the capacity of the evaporator will follow also.

President Block.—Which is cheaper, the few feet of pipe or this additional machinery?

Victor H. Becker.—More pipe will not render the service. You require such a condition of affairs as will enable your poor liquor to take up more gas.

President Block.—Instead of working with ten pounds pressure you are boosting it up to thirty?

Victor H. Becker.—That is the idea; ten, twenty or thirty pounds, according to the temperature of available cooling water.

President Block.—And you think you are effecting a saving which will make it worth while to use this booster?

Victor H. Becker.—It will relieve the rich-liquor pump of some of its work, as well as the exchanger and still.

President Block.—I do not think that it would.

Victor H. Becker.—I will tell you more about it when I read my next paper.

President Block.—I think that is taking two bites to a cherry. I have seen that experiment made.

John E. Starr.—As I understand Mr. Becker's complete statement, he expects, by using this booster, to be able greatly to increase the strength of the strong liquor in the absorber. The absorber will run at a higher pressure, and, all the other conditions being the same, the strength of the liquor can be much increased. And then, that he expects to use the exhaust steam from the engine which operates this booster in the generator, and by that combination he expects that a net gain will be made. I think that this would be a matter largely of conditions existing at the plant in regard to the handling of the water and other auxiliaries. In a great many absorption plants it is found in the ordinary operation that the auxiliaries of the plant, including, perhaps, the brine pump, the water pump and the aqua ammonia pump, will, when back-pressured, furnish steam for

the operation of the generator, and no more. That is to say, in many plants I have found that they would just balance up. Now, it is not, to my mind, possible to get very much greater economy, if you are using all of the steam which comes from your auxiliary; and as long as you are not using more, it seems that you have reached the limit of the availibility of the existing steam in the generators.

V. R. H. Greene.—There is one phase of the situation which I do not think Mr. Starr spoke of, and that is the question of pressure under which the pumps would have to work. In Mr. Becker's paper particular attention is called to the hot water, which possibly means a pressure on the generator of 20 to 25 pounds, and possibly less, due to the fact that with weak liquor—the strong liquor having to be made so very weak—if it is possible to raise that rate of back pressure, everything else being constant, you can carry proportionately less actual pressure on the generator, ignoring the question of the auxiliaries on the whole.

Henry Vogt.—Taking the gas and pumping into an absorber did not work in our own case. We tried it some time back.

John E. Starr.—I would be willing to admit that where the temperature of the condensing water is high and water of low temperature could not be obtained, there are advantages I can conceive of in Mr. Becker's plan. That is to say, suppose the water was at an initial temperature of 80 degrees; under those conditions it might be that, while the plant would be not operative under present conditions with exhaust steam, with that high temperature of the water and with only that high temperature of the water available, the method which Mr. Becker proposes would do two things. It would allow an increased pressure in the absorber, which would allow a higher temperature of water to be used in the absorber; it would present to the still a higher strength of ammonia—consequently a lower boiling point—and consequently allow a higher pressure in the condenser. I think, however, that it is hardly right to generalize and to say that such a system would be applicable under all circumstances; but I can conceive of conditions where the thing might figure out, taking everything into consideration, as an advantage to run an absorption machine in the manner indicated.

President Block.—Do you mean to say it would increase the capacity, but not the efficiency, or both?

John E. Starr.—I would prefer to say that it would increase the availability.

Henry Vogt.—In order to make myself clear on this subject,

taking the water at the temperature of 80 or 85 degrees, or even higher, and then with pumping the gas or forcing it you would get an unnatural pressure; and I do not think the absorption takes place, because the heat that is to be absorbed is done by the water itself, and it requires sufficient cooling surfaces to carry away that heat in the natural way without forcing.

President Block.—The warmer the water, the larger the absorber must be.

Henry Vogt.—Yes. Mr. Lake, of the Santiago Ice Company, Santiago, Cuba, tells me that they are running machines with water at a temperature of from 100 to 105 degrees. I would not say I would advocate it, and yet they say that they do it.

Victor H. Becker.—You could carry an absorber pressure of 15, 20 or 30 pounds with such water, and an evaporating pressure as low as the booster would maintain. You could not, of course, do that without the booster.

President Block.—You could not, of course, without the booster. You would have to take away the same amount of heat.

Victor H. Becker.—You are all after getting more gas into that warm ammoniacal water; my arrangement will enable you to do it.

President Block.—You take the heat away at a higher temperature. In order to do that you must have an increased surface to take it away, because it all depends upon the difference between the temperature of the water and the temperature of the absorber.

There is one other question I would like to ask. You stated that you used an injector instead of this booster for the purpose of injecting the gas from the evaporator into the absorber. How and why was that done? It would flow there without the use of the injector.

Victor H. Becker.—Yes; but it would not flow into any higher pressure than it then had, whereas with the injector it would. The injector would have the pressure of the poor liquor in the still behind it.

President Block.—In other words, you take that directly from the still and you form an absorber in the pipe?

Victor H. Becker.—An absorber in transit, if you please, after it leaves the injector.

President Block.—Whether that is done right at the absorber or some distance from it would make no difference.

Victor H. Becker.—The injector would drive it with the force of the poor liquor.

President Block.—That is what the Carbondale Machine Com-

pany has been doing, I believe, by having a series of injectors going into a series of pipes of the absorber.

V. R. H. Greene.—Abram Day also uses it.

President Block.—I do not know that they obtain any great advantage from it.

John E. Starr.—I noticed that in a machine of Thomas L. Rankin's, whom we all know, as far back as 1889, they used the injector principle between the expansion coils and the absorber, and, to my best recollection, they gained about three pounds. That is to say, their absorber ran at about three pounds higher pressure than the evaporating pressure on gas in the refrigerating coils.

Otto Luhr.—I would like to ask Mr. Becker whether he thinks all raw waters could be used for making transparent ice without distilling them? Some waters in some localities, I think, could not be used unless they are distilled. Since Mr. Becker expressed his opinion that by proper treatment all waters can be used to make transparent ice, I do not know whether that is the case or not.

Victor H. Becker.—I do not think it makes much difference what the water is so long as it flows over the freezing surfaces with sufficient velocity to insure constant washing of the forming ice.

Otto Luhr.—You think you could make it?

Victor H. Becker.—Yes.

President Block.—It depends entirely on the speed or velocity of flow?

Victor H. Becker.—Yes.

A. P. Criswell.—One of the subjects mentioned by Mr. Becker suggests a little apparatus that I saw a day or two ago, and which I had not seen before. I should like to ask some of the veterans here whether they have ever used it. In a cold storage plant, where they have a large amount of ordinary storage, carrying from 15 to 20 pounds back pressure to get the desired temperature, they wanted some low freezers at 10 degrees below zero. In order to do this they put a very small power compressor on the freezer suction and discharged from that into the main suction, in that way carrying a low back pressure—zero or about that—to get the low temperature in the freezer without carrying the entire system at such low temperatures.

President Block.—To my knowledge, that has been done since 1893.

John E. Starr.—To my knowledge that has been done in a number of cases. It is going on now in three or four cold storage warehouses that I know of. In one special case—in some work for

Thomas A. Edison—I used a booster exactly as described, and produced a temperature of 50 degrees below zero in a room about 16 by 16 feet and 10 feet high, which I think is the lowest temperature of which there is any record produced in a comparatively large room.

President Block.—With ammonia?

John E. Starr.—Yes.

A. P. Criswell.—How long since the small compressor was first used?

John E. Starr.—Really, I do not know when the idea was first used, but I know that it was used as long ago as 1897. This particular experiment that I speak of was in 1902.

No. 69.

THE REFRIGERATION OF DAIRY PRODUCTS.

By J. A. Ruddick, Dairy and Cold Storage Commissioner for the Dominion of Canada

(Associate Member of the Society)

In presenting this subject to the Society, I wish to remind the members that I deal with it from the point of view of the dairy expert rather than from that of the refrigerating engineer. I do not suppose that anyone will object to having the subject approached from that side, because it seems to me that the engineer must have some knowledge of dairy requirements if he is to manage the refrigeration of dairy products with complete success. If I should appear at times to wander rather too far into the field of dairying, I hope I shall be forgiven, for it was my first love, and I am still much more of a dairy expert than an engineer.

Any discussion of this subject would be somewhat simplified if we had a clearer definition of the term "refrigeration." Strictly speaking, and with regard to the derivation of the word, I suppose it means the employment of temperatures below the freezing point of water; but in practice it has received a broader meaning, and to most people the term "refrigeration" implies the employment of some mechanical or chemical system for securing low temperatures as compared with the use of ice. For the purposes of this paper, however, we shall be obliged to adopt an even broader application of the term, and include under the head of refrigeration any deduction of natural temperatures for the preservation of dairy products.

The refrigeration of dairy products may be divided under three heads, viz.: (1) the refrigeration of milk; (2) the refrigeration of butter; (3) the refrigeration of cheese.

THE REFRIGERATION OF MILK.

Housewives and dairymaids have, from time immemorial, employed a measure of refrigeration for milk when they placed it in various receptacles in cool cellars, for the purpose of securing a maximum amount of cream or to keep it sweet as long as possible. It is only within recent years that actual refrigeration has been used

in the preservation and handling of milk. Absolutely pure milk—that is, milk free from germs of fermentation, or as it exists in the cow's udder—will keep indefinitely at any temperature if protected from infection; but if any of the members of this Society were brought up on farms, as your humble servant was, they will know how impracticable it is to procure milk without more or less—generally more—impurities finding entrance into it. If the multiplication of these germs which are thus introduced is not checked in some manner, most profound changes soon take place in the milk.

I should be the last person to decry the efforts which are being made all over Christendom to obtain cleaner and more sanitary milk, because I know the need thereof; but I would emphasize the importance of cooling in that connection, because I believe it to be probably the most potent factor in preserving milk in a sweet and wholesome condition, and one that has not been given the prominence which it deserves. The process of pasteurization, very often looked upon as a heating process, is half refrigeration, because the heating without immediate and rapid cooling would, in most cases, be worse than useless. Refrigeration will not remove impurities from the milk, but it does have the effect of checking the multiplication of bacteria. It is of the utmost importance that the cooling of milk should be proceeded with as quickly as possible after it is drawn from the cow. Milk which is cooled immediately—say to 60 degrees Fahr.—will keep longer and be in better condition than if it is allowed to remain at a temperature of 70 to 80 degrees for several hours and then afterwards cooled to 40. I use these figures more to illustrate my meaning than to record actual experience. The refrigerating engineer who is called upon to design or erect a milk-cooling plant should provide for quick cooling, with as little exposure to the air as possible.

Some years ago an attempt was made to ship milk long distances in a frozen condition. Milk was sent from Scandinavia to Great Britain, covering a journey of two or three days, and it was predicted that it would be possible to ship it by this method across the Atlantic. The scheme apparently has not been commercially successful, because we have heard nothing about it of late years. One of the objections to the freezing of milk is the formation of flocculent particles of albumen or casein compounds, which are not readily dissolved when the milk is thawed. It also has the effect of collecting the fat globules into small lumps of fat.

It may be said, therefore, that for practical purposes a temperature of 40 degrees Fahr. or under is low enough for the preser-

vation of milk, and that its preservation can only be a matter of days under ordinary commercial conditions.

THE REFRIGERATION OF BUTTER.

Refrigeration is probably more useful to the butter-making industry than it is to the industry pertaining to any other food product. It is also highly essential in the practice of the art. The principal butter-making countries of the world are in the northern hemisphere, and the periods of production are more or less intermittent, owing to the fact that the summer season is more favorable for production than are the winter months. It follows, therefore, that there is a large surplus of production over consumption at certain periods of the year which must be held in reserve to supply the shortage at other periods. Before the days of refrigeration the consumption of butter during the off-season was very much curtailed, owing to the fact that it was difficult to secure supplies in good condition. With efficient refrigeration available for storing the surplus product during the summer months, consumers can now obtain their requirements in practically as good condition during the winter months as at any other time of the year. This has resulted in an enormous increase in the consumption of butter all over the world, because we spread it thicker when the quality is good, and the business of dairying has grown and developed to an extent which would not have been possible without the aid thus rendered by refrigeration.

Butter is an unstable product. It is at its best when freshly made, and its fine quality will last only a few days at ordinary temperatures in the summer months. As the temperature is reduced, the changes which take place in the butter to bring about rancidity and other undesirable flavors proceed more slowly, so that the "age" of butter is determined by the temperature at which it is kept rather than by the number of days or weeks which may have elapsed since it was made. At one time it was thought to be undesirable to keep butter below the freezing point of water under any circumstances; but gradually, in the light of experience, the storage temperature of butter has been reduced, until at the present time we have it being held as low as zero Fahr.

Experiments and investigations have shown that butter eventually changes perceptibly under any storage temperature that has so far been tried, and that the effect of storing at different temperatures is only a matter of degree and not of absolute stoppage of all change in any case.

As far as I have been able to learn from recorded experiments and observations, slightly better results have always been obtained at the lowest temperature, even as low as —10 degrees Fahr. This applies to long periods of storage, extending to six months and over. In view of this fact, one can hardly say what is the best temperature, having regard only to the best possible preservation. There is so little gain, however, when the temperature is reduced below 10 degrees Fahr. that the point of change is diminished, I think, between zero and 10 degrees above. That is for long storage. When butter is to be stored for short periods, under four or five weeks, I do not consider it necessary to go below 20 degrees Fahr. A lower temperature means unnecessary expense, because the butter should be well preserved at 20 degrees Fahr. The freezing point of butter, or, rather, of the liquids in it, depends upon the percentage of salt therein. Freezing will occur in full salted butter somewhere between 15 and 20 degrees. We have no very definite information as to whether the quality of butter is injured by freezing or not, and that is fair proof that the injury, if there is any, is not a serious one.

The engineer or cold storage manager, in determining the temperature at which butter is to be stored with an eye to economy and good results, must consider two things: First, how old the butter is and at what temperature it has been held previous to being offered for storage, and secondly, how long it is to be stored before it will go into consumption. A point worth noting in the storage of butter is that heavily salted butter does not keep as well as butter which is lightly salted. The difference has been attributed to the fact that it will require a lower temperature to freeze the highly salted butter, but experiments at variable temperatures much below the freezing point of the butter show a slight advantage in the lightly salted butter.

One of the troubles of butter storage is in the development of mold on the parchment paper lining of packages, on the surface of the butter, and even throughout its mass. Mold is a low form of plant life. It is not a spontaneous growth, but comes only from seed, just as the more lightly organized plants of the fields do. The seeds, or more properly speaking the spores of mold are very common in the form of dust almost everywhere. The conditions which develop them are dampness, suitable food and a favorable temperature, with a rather wide range, all of which are present in a butter package. The trouble can generally be traced to the creamery, where by careless handling either the parchment paper or the pack-

ages have been infected. Packages made from unseasoned wood are sometimes responsible for the growth of the mold. The salts of unseasoned wood appear to furnish suitable food for mold growth. Conditions in the cold storage warehouse may favor the development of the mold. Thorough disinfection of butter rooms at least once a year is imperative if the rooms are to be kept sweet and free from mustiness. I have found the best results from washing all interior surfaces with a solution of one part of bi-chloride of mercury to 1,000 parts of water, and, of course, everyone is aware of the beneficial effect of a periodical coating of whitewash.

THE REFRIGERATION OF CHEESE.

When we place butter, meats, fish and similar products in cold storage, we measure the efficiency of the storage and the success of the undertaking by the extent to which the goods have been preserved without change from their original condition. Produce of this kind is, or should be, at its best when first placed under refrigeration.

The refrigeration of cheese intelligently conducted is an entirely different problem, for, unlike other products for which cold storage is employed, it continues to improve in quality for many months. I am not prepared to say how old a cheddar cheese, properly cared for, will be before it reaches its best. I have kept them nearly three years with continual improvement in quality, and I wish to point out that my standard of quality is a rich, meaty texture, and a mild, though distinctly "cheesy," flavor.

Perhaps I should explain that my remarks refer only to the cheddar variety, or cheese of that type. This is the cheese which is chiefly made in the United States and is the sole product of Canadian dairies. Other varieties of cheese are not stored extensively in America.

The highest type of cheddar cheese—that which is produced in Great Britain—is never placed in cold storage, but is cured and stored at a temperature of 60 to 65 degrees, and it is at that temperature that the most desirable flavor is developed. In the United States and Canada the conditions are different, and the temperature which pervails during the summer months in ordinary cheese curing rooms and warehouses is too high for good results, as it often rises to 85 or 90 degrees. If cheese is exposed to these high temperatures for a few days only shortly after it is made certain ferments are encouraged and developed, which, if not checked by comparatively low

temperatures, will eventually produce results which are detrimental to the quality of the cheese.

The rôle of refrigeration in cheese storage is, therefore, to control, rather than to check, those fermentive changes which in most other products mean decay or at least deterioration.

It is obvious that the temperature at which cheese should be held in a cold storage will depend upon whether such cheese has been cool cured, or has been exposed to unduly high temperatures. Strictly cool cured cheese of good quality should not be stored at temperatures under 55 or 60 degrees. At that temperature the desirable flavors will develop and the texture of the cheese will continue to improve for many months.

On the other hand, if cheese has been exposed to high temperatures, the ripening processes will have proceeded further, as well as those undesirable changes already mentioned; and in order to check these injurious ferments a comparatively low storage temperature is necessary—say 36 to 40 degrees—according to the condition of the cheese. A cheddar cheese will never develop its highest quality at these low temperatures. The flavor will be lacking in that peculiar rich "cheesy" quality from which it derives its highest value. It is a case, however, of choosing the lesser of two evils. We cannot secure the fancy quality, but we prevent the serious deterioration in quality and value consequent on the development of bad flavors. These remarks apply more particularly to cheese intended for long storage.

My opportunities for studying this question have been exceptional. In 1902 I built and equipped for my government four large cheese curing and storage establishments, and operated them for five seasons, and, as a result of that experience, I was compelled to disagree with some dairy authorities who have advocated the ripening and storage of cheese at 40 degrees or even lower under all circumstances.

The shrinkage in the weight of cheese in storage is an important item in the cost of carrying it. The shrinkage of cheese while in storage at any temperature may be almost entirely prevented if the cheese are coated with paraffin wax when they are ten days or two weeks old. It will pay to "paraffin" any cheese which is to be stored for one month or more.

The practice of paraffining also prevents the growth of mold on the surface of the cheese, which may be troublesome, if excessive.

DISCUSSION.

President Block.—Mr. Ruddick, how does the low temperature in cheese-curing rooms affect the moisture contained in the cheese?

J. A. Ruddick.—There is less evaporation of the moisture from the cheese at the lower temperature than there is at higher temperatures. The shrinkage of cheese in cold storage is almost entirely the result of evaporation of moisture from the cheese, and the lower the temperature, the less the evaporation.

President Block.—Paraffining the cheese prevents that, I believe, does it not?

J. A. Ruddick.—Yes; and besides it preserves the quality of the cheese, because most of us, especially those who use cheese as a food, require that waxy, meaty texture, and the more moisture there is retained, up to a certain limit, the better texture the cheese will possess.

N. J. Waite.—I should like to ask Mr. Ruddick if he has made any experiments in storing cheese at 36 to 40 degrees Fahr. and with a relative humidity of the air? Is it not fully as important in the storage of cheese as the temperature?

J. A. Ruddick.—The humidity is important if it becomes excessive. I have not experimented very much along that line, but if you have too high a relative humidity the surface of the cheese is apt to become soft and show rot. That is the danger of too great humidity; it does not affect the cheese otherwise. At a temperature of 30 to 40 degrees I do not know what the proper humidity would be; but at a temperature of 60 degrees, which we think is the proper curing or storage temperature, we find that a relative humidity of about 85 degrees gives good results. There is a tendency to encourage the growth of mold rather rapidly with as high a relative humidity as that, but by paraffining the cheese we overcome that difficulty. The mold on the outside of the cheese does not do it any harm at all, although it spoils its appearance. If there are any cracks or openings in the rind, of course it will penetrate it. But cheese with a perfect skin is not at all injured by a growth of mold on the surface.

President Block.—You find 60 degrees to be about a proper temperature for curing or storing cheese?

J. A. Ruddick.—Yes, sir. It develops the highest flavor. Not the strongest flavor, but the highest quality of flavor—that desirable cheesy flavor which you will know if you have ever eaten a prime English cheddar cheese about a year old. It is a different thing to

eat unripened curd, which most of us are offered throughout this country. We do not know what is a fully ripened cheese. We are in too great a hurry to get our money out of it. It costs considerable money to carry cheese for any considerable length of time. In the Scottish and English dairies, where they make the real cheddar cheese—which is what we are trying to imitate in Canada—they use a temperature of about 60 degrees. The buildings in which the cheeses are stored are principally of stone, with cement floors; and the climate is not very hot, especially in Scotland, where they make cheese of very fine quality. There the temperature seldom goes above 60 degrees in the curing. They will keep those cheeses for a year, or two years, never putting them in cold storage at all. They place them on cement floors, where the temperature runs about 60 degrees. We have experimented in curing these cheeses at that temperature and keeping them for months without employing a lower temperature, and we have had better results than where we used a lower temperature, because, while cheese will ripen at the lower temperature, it does not develop its true flavor.

President Block.—After the flavor has developed, if you then store the cheese at a lower temperature, would not that preserve the fine flavor?

J. A. Ruddick.—It continues to develop and improve as long as you keep it. I have kept them three years, and they improved all the time.

President Block.—What amount of cheese does Canada export?

J. A. Ruddick.—We export about $25,000,000 worth of cheese a year. We have exported as many as 3,000,000 boxes of 80-pound cheeses, but our exports have decreased during the last few years, because we are using so much more of our dairy products at home—so many of your good citizens have come over to our side of the line to help us eat them.

W. H. Ross.—Suppose I bought a good cheese and stored it in an ordinary home cellar and kept it for a year or two, would the fine flavor be evident then?

J. A. Ruddick.—That depends. I said if you take a cheese that has never been exposed to a high temperature, then it can be kept at 60 degrees; but if you buy a cheese that has been exposed to a higher temperature for even a few days, injurious fermentation will have been started, which must be checked by reducing the temperature. In that case you require a lower temperature, from 30 to 40 degrees. The cheese which you buy in the market, and which has been exposed to a higher temperature, will not keep very well.

No. 70.

THE VALUE OF THE "FLOODED SYSTEM" AND ITS APPLICATION TO ICE-MAKING AND REFRIGERATING PLANTS.

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(Non-Member of the Society)

It is only within the past few years that a new technical term has entered into the literature of the combined refrigerating industries, the significance of which, even to the present day, is more or less shrouded in mystery to many who are directly interested therein. It is the term "Flooded System" to which I have reference, a term which defines a recently applied method of supplying liquid anhydrous ammonia to the freezing coils or other vessels in which the evaporation of the refrigerant takes place.

Before entering upon the subject concerning which this paper has been prepared—namely, "The Value of the Flooded System and its Application to Ice-making and Refrigerating Plants"—let us become clear ourselves as to just what this term "Flooded System" means, and in what respect it differs from what is commonly referred to up to the present day as the "Direct Expansion System."

It appears that the idea of the flooded system, if I am to retain this term for the present, was first conceived in the early part of the last decade of the past century in the mind of Johannes Krebs, a refrigerating engineer of Wilmington, Delaware, who, on the 9th day of September, 1890, was granted a patent covering a novel method of supplying a refrigerant—principally liquid anhydrous ammonia—to refrigerating or freezing coils, whereby, among other advantages, higher efficiency of the evaporating or heat-conducting surfaces of such coils should be obtained.

It seems, however, that this invention was never developed beyond the scope of the printing of the letters patent, owing, no doubt, to the erroneous conception of the value of its inherent principles or lack of knowledge of the actual inner workings of the apparatus as realized by the designer. It suffered the fate common to many another good and valuable invention.

It was almost ten years later when, without knowledge of the

previous invention, the same thought embodied in the Krebs patent was resumed by another and brought to realization and practical success by the addition of a seemingly simple expedient.

We all fully appreciate the fact that the cooling, or heat-abstracting, process employed in industrial refrigeration is nothing more nor less than an evaporating process based upon the principle that the conversion of a liquid from its fluid into its gaseous state can only be accomplished by the application of heat.

While the layman may not have a definite conception of the physical action attending such conversion, yet there are few who would express any wonder or surprise concerning the very common and extended practice of this principle as applied to the steam boiler. The conversion of water into steam through the transmission of the fire-heat into the water, and the consequent evaporation of the water into steam, are principles too generally understood to permit of discussion.

If, however, we descend to degrees of temperature which, in everyday language, are designated as COLD, instead of comparative absence, less intensity or lower degree of HEAT, the principles involved apparently assume a different aspect.

Yet! Without consideration of the differing qualities of the liquids employed in evaporation, there is no difference whatever in the causes which convert liquid anhydrous ammonia or water from their liquid into their gaseous states—no difference in the effect produced by such conversion.

The identical principles which govern the change of water into steam under various pressures apply equally to the conversion of anhydrous ammonia from its liquid to its gaseous state.

Supposing that we inject continuously a thin stream of *boiling* water into one end of a pipe coil which has been brought to a red heat. No one questions the fact that the injected water will be immediately converted by contact with the heated pipe surface into steam, which escapes at the other open end of the coil, nor will one be surprised to learn that the pipe itself, beginning at the inlet end, will gradually cool down to the boiling point of water, which water, in turn, while still remaining at boiling temperature, but without perceptible ebullition, continues to flow to more distant points, where the tube is yet sufficiently hot to cause further evaporation of the water.

However, the steam which is generated by this process, in finding its way to the outlet end of the coil, though in intimate contact with the walls of the tubing, exerts but little cooling effect upon

the latter, owing to its limited capacity for absorption of heat, or, in other words, by reason of its low specific heat.

But when we approach the kindred field of mechanical refrigeration, wherein this described process (although with different heat conditions of the coil and with substitution of liquid anhydrous ammonia in lieu of boiling, or even superheated water) is constantly employed, we are confronted to the present day with varying and extremely erroneous views as to what is actually taking place—views held ofttimes by men who, by reason of their long association with this industry and the responsibility of their undertakings, we should assume to be intimately familiar with the essentials of the working process entrusted to their care.

From your own experience you will undoubtedly support me in the statement that among many of the intelligent owners of ice-making and refrigerating plants and the hundreds or even thousands of their operating engineers the idea still prevails that liquid anhydrous ammonia at once "expands" or "flashes" into a gas upon its release through an expansion valve into coils of any description, regardless of the temperature at which it enters the coil or that of the coil itself, and that this gas while passing through the coil abstracts the heat from the coil, thence from the surrounding elements, such as air, water, brine or other heat-containing bodies.

Perhaps we ourselves are largely at fault for the inculcation and retention of these erroneous views by reason of the introduction and misunderstanding of such technical misnomers as "expansion cock," "expansion valve" and "direct expansion system."

No engineer or fireman has been known to call the valve an "expansion valve" through which he admits feed water to his boiler, yet it bears the identical relation to his boiler that the so-called "expansion valve" or "cock" bears to the system of freezing coils. In either case its function is to regulate a feed.

The actual generation of cold, or, rather, the abstraction of heat, is accomplished in all existing ice and refrigerating plants of any description in no other manner than that which we are used to designate as "The Direct Expansion System," a term which, though misleading, seems likely to be enduring.

The simple experiment of evaporating a small quantity of liquid anhydrous ammonia in a test bottle—where the conditions as to pressure are vastly more favorable for evaporation than those generally existing in refrigerating plants—convinces us, and should convince every operating engineer, that anhydrous ammonia can and does exist in its liquid state after having passed the "expansion

valve" of the shipping drum. It should also convince him that the intense cooling effect becomes apparent on *that* portion of the surface of the bottle only which is in direct contact with the evaporating fluid itself, and not on that which is merely touched by *expanding* or *expanded* gas.

But if the sample contained in the test bottle does not continue its violent initial ebullition or expansion—owing to a quick envelopment of the outer surface of the bottle up to the liquid line with a coating of frost, which prevents the penetration of heat—we hear more often about the wholesale condemnation of the ammonia as inferior and sluggish acting than we do about a recognition of the fact that *no fluid can be transformed from its liquid into its gaseous state without the introduction of adequate heat.*

The same process, which is so plainly apparent in this simple experiment with a test bottle, takes place in the dark recesses of every freezing coil. Only that portion of its inner surfaces which is covered by, or continuously sprayed with, liquid ammonia will be available for the really efficient abstraction of heat.

As soon as this abstraction, due to the evaporating process, has proceeded to the point where the temperature of the piping has been reduced to that of the boiling point of ammonia under the prevailing pressure, and as soon as the formation of frost around the piping retards the admission of heat, the previous rapid evaporation gives place to a slow or retarded one. The continued supply of the refrigerant will now flow tranquilly over the chilled surfaces until it reaches such a place in its travel where the temperature of its surroundings is higher than its boiling point, at which time the evaporation is resumed.

With this gradual progress in cooling, the coil, or system of coils, becomes gradually "flooded," even when, by virtue of the most perfect and approved "expansion valves," the admission of the refrigerant is so regulated as to make the quantity of the liquid supply exactly correspond in weight to that of the escaping vapor, and further providing that the entire cooling surface of the coil is brought into actual service.

To avoid any misunderstanding, we should mention in this connection that when liquid ammonia is supplied to freezing coils in the usual manner we might speak of it as "direct expanding" in a certain sense of the word, which "expansion," however, should be regarded as an unavoidable or unavoided disadvantage rather than otherwise.

To illustrate: Assuming that we operate a combination of

freezing coils under a gauge pressure of about 15 pounds and a temperature of 0 degree Fahr. corresponding, and further assuming that the liquid supply from the condenser and receiver enters the feed valves to this set of coils at a temperature of 80 degrees Fahr., it follows that with the sudden release from pressure of this liquid 80 x 1.23 = 98.4 heat units are liberated, which cause an instantaneous evaporation or expansion of some portion of this liquid supply.

In closest proximity to the point of entrance to the coils an action takes place similar to that which we may daily observe when blowing off a boiler under high pressure, or when opening one of the lower gauge cocks of the water column.

The heat stored in the water, while held under the high boiler pressure, produces an explosive-like action on the water when released from that pressure, which manifests itself in an instantaneous evaporation in every minute particle of the escaping water, tearing it at once into a spray or atomizing it.

The quantity of STEAM generated in this way, of course, corresponds exactly with the quantity of heat which, according to the pressure under which the water has been held, was in excess of that needed for the maintenance of the boiling point of water at atmospheric pressure.

The instantaneous generation of ammonia gas or vapor, due to this same cause, at the introduction of the refrigerant into a coil will undoubtedly effect a continuous spraying of the inner surface of the coil near the point of entrance. These gases, furthermore, when passing through the coils from bottom to top, provided they are of the vertical type, will also create a disturbance in the liquid which obstructs their travel to the outlet, and will thereby contribute to the attaining of an intimate contact of the fluid with the surface of the coil. In no other respect, however, can any essential value be attributed to these gases generated by this first sudden evaporation, in so far as their cooling efficiency is concerned.

The conversion of one pound of liquid ammonia at 0 degree Fahr. and its corresponding pressure of about 15 pounds gauge into vapor of the same degree of temperature requires the expenditure of 555 B. t. u.

When admitting the liquid supply at a temperature of 80 degrees Fahr. nearly 100 B. t. u. become liberated from each pound of the admitted fluid, which causes an immediate evaporation of 18 per cent. of its quantity, the temperature of the remaining 82 per cent. being thereby reduced to 0 degree Fahr., leaving only this quantity available for effective refrigeration, for the reason that the 18 per

cent. of liquid which was converted into gas of 0 degree Fahr. can barely absorb 3 B. t. u. from the surface of the coils until it reaches a final temperature as high as 32 degrees Fahr. The evaporation of a like quantity of liquid by heat exchange with the coil would have rendered an efficiency of 100 B. t. u.

This fact, combined with other obvious causes, is one of the principal reasons why prevailing high condenser pressure and correspondingly high temperature of liquid supply depreciates to such a marked degree the efficiency of an ice-making or refrigerating plant.

There are two conditions, according to what has been said heretofore, which we should bear in mind.

First—The full cooling or heat-abstracting ability of the provided coil surface can only be expected and obtained when such surface is either covered or continuously sprayed with the refrigerating liquid.

Second—The vapor liberated from the refrigerant, though having the same temperature as the former, produces only an inconsiderable cooling effect.

It is, therefore, obvious that the maximum efficiency of the total cooling surface of a vertical coil can never be obtained by entering the refrigerant at the top, as the latter would only come in contact with the lower part of the inner circumference of the piping, while the upper and larger part of the surface would merely become efficient through contact with the GASES and CONDUCTION of heat around the metal of the piping.

No refrigerating engineer would consider a brine circulating system as working to its full efficiency when each pipe line of the coil system contained but a fractional part of the brine with which it should be FILLED. How, then, can he logically permit such a condition to exist when operating only under a changed refrigerating agent but using a similar fundamental principle? When, however, the liquid ammonia is admitted to the lower end of coils of vertical type, a marked difference is evident.

We have observed heretofore that the gradual abstraction of heat from the metal of the coils and their surroundings results in retarding the evaporating process and in a gradual filling of the coils with liquid ammonia, which, under all circumstances, retains a temperature conforming to the pressure under which it is held. All heat transmitted through the walls of the coil at any point will convert a corresponding amount of liquid into vapor or gas, which, when ascending, will contribute to the stirring of the liquid and intensify

its contact with the heat-transmitting surface. It is obvious that the supply of refrigerant should be regulated in such a manner that the weight introduced within a given time equals the weight of the gas generated during the same interval.

Likewise, we should endeavor to have the entire available heat-absorbing surface continuously covered or sprayed with the liquid refrigerant, the object being, not to exchange the small amount of the sensible heat of the escaping gases, but the employment of the vastly greater amount of heat-absorbing power due to the evaporation of the liquid itself. It is the collection of the LATENT HEAT of *its gas which produces the desired results.*

In order to further emphasize the necessity of the prevalence of these mentioned conditions—the covering or wetting of the entire available heat-absorbing surface with liquid refrigerant—we might refer, for comparison, to a horizontal tubular boiler having but half of its tubes submerged in water. Can there be doubt that such a boiler will generate but half the amount of steam which would be produced under usual conditions, or that only a small portion of the heat transmitted through the exposed half is abstracted for superheating the steam, while the rest goes to waste?

Serious difficulties, however, confront us in the exercise of these emphasized and essential conditions when applied to refrigerating apparatus.

The proviso that even the outlet end of a coil shall contain liquid ammonia in such quantity as will insure the continuous wetting of its inner circumference implies that a considerable quantity of the liquid ammonia will become entrained by the escaping gas and pass with it—under the usual arrangement of our plants—into the main suction line to the compressor. We need not dwell upon the consequences!

If, however, we are in a position to intercept the cold, entrained liquid escaping from the outlet ends of the coils and to return it to their inlet ends, the harmful consequences caused by entrance of ammonia in liquid form into the compressor would be averted, and the desired result—keeping the evaporating coils suitably filled with the liquid refrigerant—would be attained.

The endeavors tending toward the realization of this idea culminated in the design of the system, which, years after its successful application to practical use, was named the "Flooded System" by one of the most eminent representatives of the refrigerating machine industry. I leave it for you to decide as to the appropriate-

ness of this name given to the child who has since grown to such lusty proportions.

It has been and still remains a fact that, in a correctly designed plant, when pursuing a *modus operandi by which the entire cooling surface of the evaporating coils is made effective,* there is just as much flooding of the coils which are fed by the so-called "direct expansion valves" as is in those which are operated through the application of the "flooded system." In other words, in so far as the *flooding* is concerned, there is no room for discrimination between the two systems; and we can only attribute to an erroneous conception of either one or both of them the application of the misleading terms by which they are designated.

Again, it may be emphasized as a fact that, in a great majority of cases wherein operation is carried on under the "direct expansion system" and wherein only a part of the provided heat-absorbing surface is made fully effective, the application of the "flooded system" would *assure* the continuous maximum effectiveness of the total heat-absorbing surface which is in contact with the surrounding medium.

Turning now to the specific and characteristic requirements which are indispensable for the attaining of such a continuous maximum efficiency, it is evident that we must look for some means of carrying out the underlying principle, as previously indicated—namely, to trap the entrained liquid refrigerant escaping from the outlet of the evaporating coils before it enters the main suction line to the compressor and to return it to the supply ends for renewed circuit.

As the entrained liquid ammonia is subjected to the low pressure of the refrigerating apparatus, it naturally follows that, unless we employ some other more complicated means, its return can only be accomplished by the natural back flow due to its own gravity; and, therefore, the reason why the flooded system has hitherto been applied only to evaporator coils of vertical type, or to such as are supplied with liquid refrigerant at the lower end, while the generated vapor escapes at the upper, becomes at once apparent.

It may further be mentioned, for reasons which will be made plain hereafter, that the "flooded system" is especially adapted for plants in which a large number or set of coils are operated in unison—an arrangement, in fact, which we generally find in all ice manufacturing plants and which may readily be provided for refrigerating plants used for other purposes.

If we insert into the suction or gas outlet pipe of such a set of

coils a vessel of comparatively large cross-sectional area in which the velocity of the gas on its way to the compressor is greatly reduced, it is obvious that the liquid entrained with the gas will be precipitated.

This vessel or liquid separator is placed on the same level, or a higher one, as the outlet header of the set of coils, and is provided on the inside with baffles or interrupters to catch and retain the liquid, in the same manner as in apparatus employed for separating water condensed in steam supply lines or entrained from boilers.

A pipe line from the bottom of this vessel or separator, which is thoroughly protected from the influence of the outside heat, to the inlet header of the battery of freezing coils, will carry the accumulating precipitated liquid back to the latter for renewed circulation, providing there is no resisting pressure which prevents its gravity flow and admission to the coils.

Such a resisting pressure would be created by supplementing, in the usual manner, the amount of liquid which has been converted into gas—i. e., by supplying it from the high-pressure side of the system directly to the inlet header—owing to the fact that the instantaneous evaporation of a portion of this supply, for reasons previously mentioned, would generate sufficient pressure to prevent or obstruct the free flow of the returning liquid under a comparatively low head.

It is, therefore, necessary to introduce the liquid by which the amount of evaporation is restored (and which in every way may be compared with the feed water supplied to a boiler) TO THE VESSEL in which the ENTRAINED liquid is precipitated, and which we will hereafter term the "Accumulator," whence it will then flow, in company with the "accumulated" liquid, to the inlet header connecting the coils.

It appears that the realization of Mr. Krebs's idea or invention failed only by reason of the manner in which the admission of the supplementary liquid to the accumulator was intended, and perhaps put into practice, because we must bear in mind the fact that the liquid ammonia coming from the condenser and receiver is held under the high pressure of the system at a temperature which conforms to that pressure, while the accumulator is under low pressure and correspondingly low temperature. Should the liquid supply be admitted to the accumulator through a suitable valve under high pressure and temperature, we would observe the same action—were the accumulator transparent—as becomes visible upon the blowing

off of a boiler under high pressure or opening the gauge cock of a water column below the waterline.

The inner heat of the liquid, when released from pressure, becomes immediately active, and the explosive-like evaporation, which occurs in its every particle, results in a spraying or atomizing transformation. A large portion of this atomized, fog-like ammonia would be carried along to the compressor by the current of the return gas, even when traveling at low velocity, and thereby miss its destination.

Lacking the appliances to effectually obviate the entrainment of such finely atomized fluid, it would occur to us to look for means which will prevent this spraying or atomizing action at the outset. We know the *cause* and have the *remedy* at hand, which simply consists in abstracting from this supplemental liquid supply, while still held under the high pressure of the system, such an amount of heat as is necessary to reduce its temperature to that degree which conforms to the low-pressure temperature.

This being accomplished, upon entrance of the liquid ammonia to the accumulator there is no more cause for and no possibility of its partial evaporation and atomization. The formerly disturbing element in the application of the "flooded system" has been removed and a compact body of the liquid—equal in weight to that of the returning dry and saturated gas—will flow continuously from the accumulator to the inlet header of the coils.

Thus we realize that the mechanical appliances necessary for the successful application of those principles which we now call the "Flooded System" must consist of a reservoir or "accumulator" inserted into the suction line of a refrigerating apparatus, in which the entrained liquid, returning from the freezing coils, is intercepted—a cooling device by which the temperature of the liquid supply, while held under high pressure, is reduced to that which conforms to the low pressure of the system, and a pipe connection between the elevated accumulator and the supply or distributing header connecting the freezing coils, through which the liquid will flow by its own gravity to freezing coils.

Inasmuch as the supply of the refrigerant to the coils and its uniform distribution to them is governed solely by the laws of gravity instead of by pressure and hand-regulated valves, as usually employed, it might be appropriate to designate the one as "Gravity Feed System" in contradistinction to the other, which should then be termed "Pressure Feed System." Thus naming them, the thinking refrigerating engineer could not take exception to the adopted terms,

and we should be following approved methods of technical nomenclature, in which the essentials and characteristics of a subject find expression.

The explanation of the underlying principles and the description of the mechanical appliances of the gravity feed system make the value of its application to ice-making and refrigerating plants evident.

Relying with absolute certainty upon the fact that every square foot of heat-absorbing surface is made fully efficient through being in continuous touch with the liquid refrigerant, and knowing the amount of heat which, in a given time and under defined conditions, will be transmitted through each square foot of coil surface, we should be able to determine the requirements of the latter, within narrow limits, for any specified capacity, and also to become indifferent as to the employment of such surface by the operating engineer in charge, the regulation being automatic and requiring no attention.

The possibility, or even the unavoidableness, of utilizing the entire heat-absorbing surface continuously makes it apparent that in comparison with usual practice we can largely reduce this surface without curtailing the capacity of a plant, or that we can greatly increase by the gravity feed system the efficiency of existing plants by the application of this means for the utilization of its entire cooling surface, providing the displacement of the compressor is sufficient to take care of the increased volume of gas.

Fluids, when entering a number of vessels through a communicating pipe, will, in accordance with the laws of gravity, seek a common level. The gravity feed system, therefore, provides a means for a uniform and equal distribution of liquid ammonia from a central point to any number of freezing coils which are integrally connected and placed on the same level; and as the entrained liquid returns for renewed circuit through these coils, there remains no reason why the admission of the refrigerant should be gauged by the intensity of the evaporation or by the amount of gas escaping from any particular coil, as it is the *total* efficiency of *all* the freezing coils which needs consideration. The efficiency stands in direct relation to the daily capacity, which is subject to but slight fluctuations, and for the production of which nearly the same quantity of refrigerant must be evaporated daily. Thus we may have no care regarding the changes occurring in individual coils, as far as the intensity of the evaporating process is concerned.

Here, again, we may well compare the gravity feed system with

a battery of many boilers held under a uniform pressure, supplied by a single feed pump and maintained at a uniform water level by a large sized pipe, which communicates with the several units below the waterline.

The gravity feed system requires but one valve through which the quantity of the *daily* supply of the refrigerant is admitted, regardless of the requirements of each individual coil, in lieu of the many expansion valves, by the use of which, with every careful attention, the admission of this liquid can never be accomplished in a manner to conform to the ever-varying conditions prevailing in the various coils.

We meet with one of the most illuminating illustrations touching the variations in evaporating capacity of coils when considering the action in plate ice freezing plants of that type which employs the coil itself with its sheet-metal facing as a congealing surface. The evaporation of the refrigerant, during a freezing period of from five to six days, commences in such coils with a maximum intensity, so long as the coils are bare of ice, and decreases to a minimum proportionally with the gradual increase of the thickness of the ice collecting on both sides of the plate and resisting the transmission of heat inwardly.

A proper adjustment of the ammonia supply to meet such ever-varying conditions by means of hand-regulated feed valves is a practical impossibility, and it may reasonably be claimed that the revival and improvement of this method of manufacturing ice which has been witnessed within the past few years are due in large measure to the application of the gravity feed system.

Whether a proportionate number of freezing plates or coils are in the initial, intermediate or final stage of the freezing process and consequent operating activity, the total requirement of refrigerant for twenty-four hours remains about the same, in accordance with the daily product of the plant. Nor does the freezing efficiency or intensity in any of the coils undergo any change whatever, even when the evaporating process in a larger or smaller number of them comes almost to a standstill, and when, in consequence thereof, these coils fill with refrigerant in which but very few gas globules are ascending, because the temperature of the liquid refrigerant remains at that degree which corresponds with the pressure under which it is confined.

Equally good results are obtained by the use of the gravity feed system in connection with can-ice plants. No reason appearing for the surveillance or control of the single coils at their inlet or outlet

ends, the manifolds connecting them may well be placed inside the freezing tanks, thereby converting a source of loss, through exposure of these headers, into one of gain by increased effective cooling surface.

Then the adjustment of a single regulating valve governing the total supply of the refrigerant permits us to either render the entire heat-absorbing surface of all the coils effective or to make only a portion available, as in present practice, with this discrimination, however, that when supplied by gravity feed the distribution to the coils is uniform, and *each* coil shares alike in the abstraction of heat from the brine in which they are submerged.

When we consider the fact that the gravity feed system can be applied to all kinds of coils of the vertical type, we are not surprised to learn that it does excellent service in connection with batteries of double-pipe brine coolers.

Owing to the rapid evaporation, violent ebullition, which takes place in this effective type of cooling apparatus, and the small chamber or annular area through which the gases must pass on their way to the outlet, there is more opportunity for entrainment of liquid ammonia in the working of these coolers than obtains in those of the single-pipe type, unless in the former the supply of refrigerant is curtailed to such an extent that its evaporation is completed before any of it reaches the outlet. This curtailment, for reasons sufficiently explained, would render the upper pipes of the coolers rather ineffective.

As a matter of fact, we find refrigerating equipments in which twenty and even forty of such double-pipe brine coolers are employed, with a capacity range of five hundred tons refrigeration and over, wherein of all these coils, being supplied with refrigerant through one single controlling valve, each contributes its full and equal share in the total refrigerating duty performed, and the economical efficiency of the compressors is not in the least impaired by the entrainment of liquid or so-called wet gases.

What has been said concerning the advantages of the gravity feed system in connection with double-pipe brine coolers relates as well to the application of this system to vertical type evaporating coils employed for the cooling of air, with or without forced draft arrangement. Equipments of this kind, for maintaining low temperatures in cold storage rooms and for attainment of high efficiency in the cooling of chill rooms, are being introduced step by step, and it is the general consensus of opinion among those who were sufficiently intelligent and progressive to make use of its merits—after

being fully protected by strong guarantees on the part of the makers—that the gravity feed system is superior to other methods heretofore employed.

To summarize its valuable features, when properly applied:

First.—It admits of the use of the entire cooling surface of refrigerating pipe to its full extent and highest efficiency without apprehension of impairing the efficiency of the compressor.

Second.—It eliminates the numerous feed valves and the attention required for their regulation.

Third.—It renders the supply of the refrigerant automatic in strict relation to the needs of every individual freezing coil and irrespective of the conditions under which it may be working.

Fourth.—It furnishes the means of operating an ammonia compressor under the most favorable conditions at which it receives the gas in an almost dry or saturated state, its temperature conforming to its pressure, and discharges it with somewhat less superheat than is due to the ratio of compression.

In conclusion, let us direct attention to a unique behavior of the refrigerant in the gravity feed system, thus far only made serviceable to a limited extent, but capable of further development. It will be readily understood that the pipe line conducting the refrigerant from the accumulator to the supply header connecting the evaporating coils is continuously filled with the fluid refrigerant in compact form—that is, with a liquid which is not intermingled with gas globules due to partial evaporation; and it will be as well understood that the liquid ammonia contained in the evaporating coils, owing to its exposure to heat, is in a state of constant ebullition, in which it is more or less intermingled with gas ascending to the outlet.

The weight of the compact column of fluid in the feed pipe, however, is greater than that of an equally high column of the refrigerant in its state of ebullition as contained in the evaporating coils; and as, according to the laws governing liquid levels in communicating pipes, these columns will not balance, it follows that the heavier one displaces the lighter, resulting in a continuous natural circulation of the refrigerant through the evaporator coils, which assists or intensifies that which is caused by the ascending gases.

The cause and effect of this occurrence may be properly compared with those brought into action when elevating water from deep wells by means of compressed air. The outside compact column of water lifts the inner one, which, being lightened when disintegrated by the introduction of the myriad particles of air with which it commingles, rises to a considerable height.

It may, therefore, be reasonably expected that, in due course of time, the gravity feed system will be developed to that extent where we shall entirely discard those systems which circulate intermediate heat-absorbing agents and which to the present day are so much in vogue by reason of their generally uniform action. In their stead we may eventually contrive an automatic circulation of the evaporating refrigerant itself and regulate its temperature, in accordance with the requirements, by control of the pressure, at which we shall permit the generated gas to escape from the respective coils.

The losses incident to the use of intermediate cooling fluid could thereby be avoided and the direct influence of the refrigerant, with its attending low temperature, be attained without parting with the advantages which are now derived from the employment of the former, and all by the enlargement of the field of application of the gravity feed system.

DISCUSSION.

President Block.—Do I understand that you can feed, by an expansion valve or cock, the liquid ammonia into an evaporating coil and flood it; and if you had cooled the liquid to a temperature at which it evaporates before it reaches the expansion valve, the coil surface would then have exactly the same efficiency as it had in a gravity-feed system? That the only difference between the gravity-feed system and the flooding of the coil by a separate expansion valve is that in the gravity-feed system you have an appliance for taking out the entrained liquid and returning it again to the expansion coil, instead of sending it back to the compressor? Is that the clear difference between the two systems?

H. Rassbach.—When a coil is fed in the usual manner, by an expansion valve, it becomes gradually flooded in proportion with the decrease of temperature of the brine or other medium in which it is submerged. Its efficiency will be the very same whether the liquid be supplied by an expansion valve or by gravity-feed, or whether the liquid is precooled or not, providing the feed in the former case —by expansion valve—is regulated so that all pipe lines of the respective coil are partially filled with liquid.

The difference between the two systems is, principally, that by direct feed or pressure feed such partial filling of all pipe lines cannot be accomplished without danger of passing liquid over into the main suction and the compressor, whereas the gravity-feed system permits of an unrestrained supply and filling of all pipes with liquid because the unevaporated portion of it which escapes from the outlet

end of the coil, or any number of coils, is carried back to the inlet side for renewed circuit and action.

For fear of too heavy back-freezing or drawing of liquid into the compressor, we seldom or never avail ourselves of the entire cooling surface of a coil, and are careful in supplying only so much liquid to it as can or will evaporate *entirely* BEFORE any liquid reaches the outlet end of the coil. But since the *ammonia* GAS returns from the freezing coils with no higher temperature than the brine in which they are submerged—say 16° Fahr.—the outlet ends of these coils are bound to show a frost-covered surface outside of the tank.

President Block.—For a short distance?

H. Rassbach.—For a short distance only; which is proof or evidence that there is no more liquid present at or near the outlet end of the freezing coils, and nobody knows how far back from it. The outside frosting of the return ends is merely caused by the flow of cold *gas* of, say, 16° Fahrenheit, through them, which, by the transmission of a small quantity of heat from outside, is warmed to above freezing point when the outside frosting disappears.

Providing the freezing coils are built eight or ten pipes high, there is no saying whether only two or four or more of these pipes are actively engaged in the abstraction of heat by containing *liquid* ammonia apt to absorb a large amount of heat for its conversion into gas. The return ends of the coils are frosted just the same for reason of the flow of cold gas through them, and therefore furnish no clue for determining the proportion of the coil which is really effective to its *full* extent by containing liquid to which the heat transmitted from outside can be transferred.

I claim that in feeding a number of freezing coils by means of individual expansion valves we are never certain as to how many coils, or how many feet of pipe in each coil, are made fully available for freezing purposes; whereas the application of the so-called flooded system permits and furnishes the means for keeping liquid ammonia present in every pipe, thereby rendering the entire cooling or heating surface of the coils fully effective at all times.

President Block.—That is exactly the proposition. The difference is, then, that in the one case your liquid, if it does go out from the tail end of the pipe, goes directly back to the compressor, and in the other case it is intercepted and is again sent into the expansion coil?

H. Rassbach.—Yes, sir.

President Block.—I wanted to make that clear.

Charles E. Lucke.—I note several references in the paper to

the desirability of keeping the coil surfaces wet. If there is any improved action under those circumstances, over the other so-called series feed, it ought to appear in the form of an increased average rate of heat transfer. Will Mr. Rassbach give us what he considers the average rate of heat transfer through an ordinary coil feed under the old system, and the same figure for the same coil feed under the flooded system, so that by comparing those two figures we can arrive at some idea of the relative value or effectiveness of the surfaces?

H. Rassbach.—There is no difference or improved action in the form of an increased rate of heat transfer between the ordinary coil feed under the old system and the flooded system, because the coëfficient of heat transmission or the conductibility of the metal through which the heat must pass before reaching the refrigerant which finally absorbs this heat, and is thereby converted into gas, remains the same in both cases.

But when, in the case of the ordinary coil feed, a large percentage of the piping does not contain any *liquid* refrigerant, but merely gas of insignificant or no heat-absorbing power, it follows that the heat transmitted through the walls of those pipes finds nothing by which it can be taken up and carried off. To illustrate: The conversion of one pound of liquid ammonia into a pound of gas requires the expenditure of 555 B. t. u.

President Block.—Under certain conditions?

H. Rassbach.—Under certain conditions, which are, that the liquid be evaporated under approximately 15 pounds gauge pressure, or 0° Fahrenheit. Now, providing the evaporation of this one pound of liquid is accomplished in the first 20 feet of length of a freezing coil, but the one pound of gas into which it is converted, and which also has a temperature of 0° Fahrenheit, flows through a second 20 feet of length, or any additional coilage, then you will admit that the first 20-foot length of the coil has been active to the extent of abstracting 555 B. t. u., while the remainder could only transmit or get rid of as much heat as is required to heat the one pound of gas from 0° Fahrenheit to whatever the temperature of the surrounding brine may be, and which may not take more than perhaps 20 B. t. u.

If *every* 20 feet of length of the coil had contained one pound of *liquid* for *evaporation,* each one would have contributed a cooling effect of 555 B. t. u. I do not know whether I made myself plainly understood in this direction.

Charles E. Lucke.—Perfectly; but you have only repeated what you said in your paper. What I am trying to get at is this: If that

pipe is more effective in the one case than in the other, then more heat can pass through one hundred linear feet of pipe in the one case than would be possible in the other case, assuming the same back pressure.

H. Rassbach.—It is not only a question of the heat passing through the metal of the piping, but a question of whether or not there is anything present or existing inside of the pipes to which this heat can be transferred after it has reached the interior of the piping, and which has sufficient capacity for absorbing and carrying off the heat.

Charles E. Lucke.—Assume they are capable of heat absorption?

H. Rassbach.—I cannot assume that, because they are not capable of absorbing the heat. The heat from the brine will be transmitted undoubtedly to and through the metal of the piping, but if these pipes contain nothing but gas, which can only take up a very small amount of heat before it reaches the same temperature as the surrounding brine, then the larger amount of this transmitted heat is not taken away and carried off so as to make room for subsequent heat transmission.

Charles E. Lucke.—Can you give me the number of feet of pipe required to present the necessary cooling surface?

H. Rassbach.—We can only approximate this. We know, however, that with a reduction of some 30 to 40 per cent. of the cooling surface employed in the ordinary practice, we still obtain the same results when such reduced cooling surface is made use of in its entirety by the application of the flooded system.

Charles E. Lucke.—Thirty to 40 per cent.?

H. Rassbach.—In other words, we have used in ice making plants built heretofore from 30 to 40 per cent. more cooling piping than would have been necessary if all the applied cooling surface had been made fully effective.

Charles E. Lucke.—Then the average heat transfer should vary in just that proportion, should it not? That is what I am trying to get at.

H. Rassbach.—I would not like to be misunderstood in regard to this heat transfer. The heat transmission through the iron piping, that is to say, its ability or capacity to conduct heat from one medium to the other, is and remains the same in both instances. In one case, however, this heat finds a body to which it is readily and amply transferred or by which it is absorbed, and in the other case does not.

Charles E. Lucke.—By heat transfer, of course, I mean the co-

efficient — B. t. u. per square foot per degree per hour. That is the unit.

President Block.—In order to make it plainer, Mr. Rassbach, will you assume a certain condition? Say a plate ice plant in which the surface is in contact with the water at a temperature of 32 degrees. You have stated somewhere in your paper that perhaps for two hundred feet, or for a certain distance, the coil may not be efficient, because there is nothing to absorb. The rest of the pipe will then increase in efficiency, and in heat transmission, because there is something to absorb. If you assume that condition, and state the difference between a gravity-feed system and the direct-expansion or single-feed system for each coil, I would be glad to have you do so. Will there be any difference? Will the gravity-feed system absorb any more heat units per square foot of surface in that portion in which it can absorb than the direct expansion?

H. Rassbach.—It certainly will not. If you were able to supply the individual coils by hand-regulated valves in such a manner that *liquid* ammonia is always in contact with the entire cooling surface presented by the coils, one system would be just as effective as the other.

President Block.—That is what I wanted to make clear.

H. Rassbach.—Under the circumstances just named there would be absolutely no difference between the two systems. Referring, however, to plate ice freezing plants, you are fully aware that conditions for evaporation are changing in the individual freezing coils, you may say, every minute. The ice collecting on the plates is gaining continuously in thickness, and hand-regulated valves for each coil would have to be continuously adjusted to make the liquid supply conform to these ever-changing conditions.

Considering the large number of freezing coils usually employed in plate plants, and the corresponding number of valves which should have careful and everlasting attention, I venture to say that it is practically impossible to regulate them so that no *liquid* will pass through the main suction to the compressor, providing the upper pipes of each coil are held partially filled with liquid. And this latter condition is an essential one in order to obtain ice of uniform thickness at top and bottom.

I will mention in this connection that in former practice complaints were frequently heard that plate ice would freeze thinner on top than near the bottom. We find just the reverse with the gravity-feed system because the upper pipes of the freezing coil are under a lower pressure, and consequently at a lower temperature, than those

near the bottom, in which the evaporation of liquid takes place under the additional pressure of the column of liquid or resistance of liquid contained in the upper part of the coil. This difference in thickness, owing to more rapid freezing under the lower temperature at the top, is more perceptible in winter than during the summer, when the conduction of heat through the tank lids has a marked influence on the freezing.

Robert A. Whelan.—In the accumulator system, you speak of the returning gas carrying over entrained ammonia, the ammonia being intercepted in the accumulator and returned to the manifold on the coil. That, of course, makes your gas lighter in weight. In changing from a standard to a flooded system will it not require a greater cubic capacity in your compressor to handle the increased volume of ammonia gas?

H. Rassbach.—I do not see how the weight of the gas should be decreased by this process. It is merely freed from the entrained liquid when passing through the interceptor or accumulator. We do not care for getting liquid into the compressor, but want to make use of it in the freezing coils. The accumulator is nothing but a chamber through which the gas, which is generated in the coils, passes on its way to the compressor, and in which the liquid entrained with this gas is collected to be returned to the inlet end of the freezing coils. The accumulator has the same relation to the freezing coils as a steam drum has to the tubes of a water-tube boiler, and as far as decreasing the weight or density of the gas is concerned when passing through this drum, there is nothing whereby such action might be caused.

President Block.—The gas is of the same weight as long as it is at the point of saturation?

Robert A. Whelan.—What I was getting at is this: If the saturated gas coming over was not intercepted in the accumulator, it would go to the compressor and be heavier, and the compressor in compressing it would deliver more liquid.

President Block.—It will not be heavier, after entrained ammonia is taken out. The entrained liquid would only do harm in the compressor. What I understand Mr. Rassbach to say is, if you have twelve coils and they are fed by one accumulator tank, and three of these coils are turned on today, supposing that the ice has just been harvested this morning, and the valves are opened again, and the ammonia flows into these coils, the three of them you have turned on yesterday, and the three the day before that, and the three the day before that—the three which were turned on four days ago

will not require as much liquid ammonia fed into them as those which were turned on today, or those turned on yesterday, or those turned on the day before yesterday. Your claim is that, nevertheless, as much ammonia will be supplied to those coils as they can evaporate?

H. Rassbach.—Yes, sir.

President Block.—Owing to the fact that the heat will act upon the liquid in the coils, which is solid in one case, partially solid in the other, more than half gas in the third, and nearly all gas in the fourth? Is that the idea?

H. Rassbach.—It is. Of course, as the gas has the same temperature as the liquid from which it generated under a certain pressure, it might be immaterial whether the pipes are filled with cold gas or cold liquid. As a matter of fact, I prefer the liquid for reason of its much higher heat-absorbing power or capacity. We clearly note this, for instance, in the process of beer-cooling, when done either with brine or direct expansion of ammonia. In the former case we make the entire cooling surface of all the pipes of a cooler effective and obtain corresponding results, while in the latter the pipes are to a great extent ineffective because they carry gas with an insignificant amount of heat exchange capacity.

President Block.—That may be due to the difference in the speed of the two fluids, the one being altogether liquid and the other being only partially so.

H. Rassbach.—At the same time you will admit that the liquid ammonia under fifteen pounds pressure should always have a temperature of zero Fahrenheit?

President Block.—Yes.

V. R. H. Greene.—This subject of the increased rate of heat-transfer due to the presence of liquid ammonia in the flooded system has developed such a keen interest that it has prompted me to secure records of plants operating under this system, and this I am desirous of bringing before this Society for its consideration.

President Block.—I understand that you have gathered such data?

V. R. H. Greene.—Yes, from actual tests in and around New York City.

V. R. H. Greene.—If the Flooded System is to be an epoch-making improvement in mechanical refrigeration and the manufacture of ice, it must possess some advantages beyond any that seem at present to have been realized. It must permit of cheaper ice-making, the cost to include first cost to the purchaser, and less labor cost

by means of a mode of operation far less complicated than the system at present employed, with greater certainty of freedom from interruption.

The old style can plants, as formerly put upon the market, contained from 14 to 15 three-hundred-pound cans per ton of ice, and an average of 300 lineal feet of 1¼-inch pipe. With these plants nothing but a condensed water cooler was used to cool the water entering the cans to about 70 degrees Fahr. Under these conditions and with a brine temperature of 14 degrees Fahr., the freezing time varied between 50 and 54 hours.

With or without justification the installation of the flooded system was accompanied by a reduction of the number of cans to 12 and the expansion piping reduced from 300 to 180 feet of 1¼-inch pipe per ton of ice to be manufactured per day. This seemingly large reduction in the pipe surface was thought to be proper because of an expected increase in the rate of heat transfer between the evaporating ammonia and the brine. On this new basis many plants were installed during the year just passed and existing installations altered on a guarantee to increase their capacity at least 10 per cent.

A careful investigation of the plants operating under this new system in and around New York City has shown that expectations have not been realized. The capacity of the ice plant has fallen off sometimes as much as 20 per cent., instead of being increased, even in spite of the addition of a distilled water forecooler lowering the can water to 40 degrees Fahr. or less, which in itself, without any change of system, should increase the capacity 16 per cent. over what would be possible with the 70 degrees water with everything else the same.

Whether 12 cans or 14½ cans per ton are required depends upon the temperature of the water entering the cans and the brine temperature, as these together fix the rate of freezing, and not at all on the heat-absorbing effectiveness per square foot of pipe surface, The reduction of capacity noted seems to be due to insufficient piping surface, for, if the 180 feet of 1¼-inch pipe per ton supplied to the new system be capable of only four-fifths of the capacity of the old plant, then it might be assumed that $5/4 \times 180 = 225$ feet of pipe will be capable of making the original capacity. With the original initial temperature of water of 70 degrees Fahr., ice made and cooled to 20 degrees in 14 degree brine requires 186 B. t. u. per pound, whereas only 156 B. t. u. is necessary with 40 degrees water, a reduction of 16 per cent., and this would be a possibility in the old system. This method with $\frac{156}{186} \times 300 = 250$ feet of pipe. It thus appears

that the old system can do as well as the new system is doing, if it has 25 linear feet of pipe more than supplied, so that this length of pipe provides the same separation element as the tanks, reservoirs or accumulators of the flooded system.

It has long been generally recognized as undesirable to allow liquid ammonia to enter the compressor cylinder. For this reason, undoubtedly, more pipe was put into the old-time freezing tanks than was actually needed to perform the work, the additional piping acting as an element of safety by allowing of separation of entrained liquid from the gas.

If formerly it was actually possible to control the expansion valves when 300 feet per ton was used and later 16 per cent. of the cooling duty removed, it must remain practicable to control the expansion on the correspondingly reduced pipe length of 250 feet, as that same margin would still be present, provided, of course, the lengths of coils per expansion valve be proportionally reduced. If, however, that margin be removed, trouble may be expected in the control of the plant. In the flooded system it was thought that the accumulator would make this close working a safe proposition. This has been shown not to be the case. Complaints of plant engineers operating this system to the effect that there are heavy ammonia losses and shut-downs, due to the necessity of too frequent packing, such as results from liquid carried over to the compressor, show at least ineffective separation in the accumulator.

Under the old standard process of ice-making it was always possible with a steady ice pull to have a brine temperature of 14 degrees Fahr., with 18 to 19 pounds back-pressure, and, as this corresponds to 4 degrees Fahr. ammonia temperature, this is equivalent to a difference of 10 degrees between the gas and brine.

Various records from the operation of the flooded system have shown that with 15 pounds back-pressure, corresponding to 0 degree Fahr. ammonia temperature, brine is maintained at 10 degrees, which indicates identically the same temperature difference between the brine and ammonia as is found in the old system.

In these flooded system plants ammonia would follow down the piston-rods as soon as liquid ammonia became visible in the accumulator gauge glass, the compressor discharge temperature falling at the same time to between 80 degrees and 90 degrees Fahr. Two of the plants put into the system during the four summer months 3,500 and 4,800 pounds of ammonia, respectively, in addition to the prime charge as specified in the contract for a 50-ton plant working on the flooded system, and both plants are still short of ammonia. It also ap-

pears that the operating engineers have been able to get more capacity than the erecting men by disregarding instructions and neglecting the ammonia level in the accumulator, feeding just enough into the by-pass under the accumulator to show a clear frost on the return header—the very same guide as is used on the old system. Another difficulty that should be noted in flooded system operation, with the ammonia out of sight in the accumulator, is unequal feeding of the coils, causing many cakes of ice to be more or less cupped.

In conclusion, from these observations it may be said that there is no evidence of an increased rate of heat transfer between the coils and the brine in the flooded system over the old system, and that, therefore, there is no apparent reason for reduction of pipe, except as the accumulator acts in a separating capacity similar to a short additional length of pipe. The number of cans per ton, being a consequence of water temperature and brine temperature solely, is naturally not at all related to the peculiarities of heat transfer between piping and the brine, and the practice adopted in the flooded system installations of using less cans is justified solely by the addition of more effective forecooling apparatus, an addition not at all peculiar to the flooded system, and an addition which at the same time has served to obscure the precise effects of the flooded system as such.

Walter S. Ashton.—I believe I can give a little information which will bear out Mr. Rassbach's statement. In one of the plants of which I have charge we have two ice-freezing tanks, identical in size, the same number of feet of expansion pipe, and the same number of cans of the same size. Last winter we changed one of them to the flooded system. I did not have any idea that I would want to speak on this subject, so I have no data with me; but the results were that during this last summer the old-style tank made 50 tons of ice a day, while the flooded system tank made 56 tons of ice per day. That is a practical result.

Fred W. Wolf, Jr.—Would not the advantage that seems to occur be from more uniform distribution, would not that explain Mr. Ashton's results?

President Block.—To a great extent, yes.

Fred W. Wolf, Jr.—As a matter of fact, would not his own statement, that he had ten coils, with maybe six or maybe eight or maybe ten with gas in them, explain his own results; that is, the advantage which simply comes about from a better distribution?

In England, for instance, the same practice of coil reduction probably obtains which exists in Mr. Rassbach's flooded system plant.

As a matter of fact, they do it with a rotating distributing cock, which gives a better distribution and makes the same number of active coils possible. Would not that explain the entire advantage, if there is any, of the flooded system?

H. Rassbach.—I do not know where and how Mr. Greene has gathered the data just presented, but it will seem to me that reducing the number of coils or cooling surface, and *also* reducing the number of cans and *still* looking for the same results from a plant operated by application of the flooded system, is going entirely too far. It is unwarranted to expect higher efficiency to such an extent.

We may reduce the number of feet of piping employed in the freezing coils below that formerly used, but by no means the number of ice molds at the same time. The cooling surface may be reduced, because of the surface provided under the ordinary coil-feed perhaps no more than 80 per cent. was brought into actual service, and 20 per cent. remained rather ineffective for the cooling of brine, as that much of the piping contained only gas, which would absorb but very little of the transmitted heat. Therefore the removal of this 20 per cent. of ineffective piping cannot have any effect on the final result, providing care is taken that by applying the flooded system the remaining 80 per cent. is always made fully effective.

Nor should the promise be made that by the mere application of this system the capacity of any given plant can be increased, unless the displacement of the compressor is such that it can handle the larger volume of gas which is generated in the existing coils whenever their *entire* surface is brought into service as effective evaporating surface. This is not done in the majority of plants or in no plant where the coils are fed with a number of expansion valves.

On the other hand I am not positive what kind of a system Mr. Greene had reference to, as he spoke about gauge-glasses attached to the accumulator and other things which I am not familiar with. There may be a great difference between the flooded system he experimented with and the one I have in mind. The only way to make the so-called flooded system correct and perfect in its operation is by precooling the liquid before it enters the chamber, or the accumulator, from which it distributes itself to the coils by gravity flow. Unless the liquid, before being relieved from pressure, is first brought into a condition in which it will behave like any other ordinary fluid after the pressure has been removed, it will not and cannot follow the law of gravity flow. Its inner heat will cause

its partial evaporation and a disintegration of the whole body of the incoming liquid. It should first be subjected to a treatment so it will flow in the same manner as water flows from a bottle into a glass and the precooling is or constitutes the proper and *only* treatment to that end.

President Block.—In other words, you consider it requisite to cool the liquid ammonia down to the temperature at which it evaporates afterward, before it enters into the accumulator?

H. Rassbach.—Undoubtedly so. Because if the liquid is not precooled we lose quite a percentage of it, in the first place, by evaporation due to the consumption of the excess of its inner heat. But this is not the principal loss. The principal loss is caused by the fact that the entire quantity of the liquid supply would enter the accumulator in the form of a spray, for reason of the action of the inner heat of the liquid on its release from pressure, and this spray of liquid would be carried with the current of the return gas to the compressor, and in this way be lost; not doing its work in the freezing coils.

John E. Starr.—As to the purely physical conception of this action of the ammonia, Mr. Rassbach very appropriately described or drew a parallel between the action of the boiling ammonia and the action of the boiling water. In order to simplify the matter a little, I would suggest that we take the conception of a return-tubular boiler, which I believe represents the largest disengaging surface between the water and steam of any type of boiler. The coil with the accumulator, which Mr. Rassbach has described more particularly, refers to what might be called a water-tube boiler, where the steam is generated in the tube and bubbles out with the water into the drum, and there the steam is separated from the water. I have made some investigation of this subject and have consulted somewhat with Professor Jacobus, who is an acknowledged authority on the generation of steam, and, omitting certain minor details, which I think we need not discuss here, Professor Jacobus and myself agree that the square feet of disengaging surface as compared with the cubic feet of gas, whether of steam or ammonia, or any boiling liquid, was the proper relation to study. In a return-flue tubular boiler, if I remember correctly, about three cubic feet of steam will be disengaged per square foot of disengaging surface, that is, between the water and the steam, with boiler pressure at 100 lbs.

President Block.—Per minute, or how?

John E. Starr.—Per minute. Returning to what might be con-

sidered perhaps a type of boiler which has the least disengaging surface, the Maxim boiler, in that boiler about 11 cubic feet of steam is disengaged per square foot per minute.

The return-flue boiler gives fairly dry steam. The water-tube boiler gives fairly dry steam unless you push it a little, when the water commences to rise, and if you push it still further it commences to throw out more or less water with the steam. I made a direct experiment with such a boiler by running it at 150 pounds pressure, running it on an engine, and wasted a certain portion of the steam (all that was not used in the engine), running the boiler at its rated capacity of 150 pounds. I then tried running the same boiler, pumping in the same amount of water, and endeavored to evaporate the same amount of steam at 100 pounds pressure, again wasting what steam was not taken up by the engine. The result was as might be expected, steam so extremely wet that we had to stop the engine.

In other words, it shows the principle that the cubic feet of steam per square foot of disengaging surface is the principal governing factor as to the dryness of the steam.

Now to return to the question which we are considering: For a moment eliminate the question of the number of coils discharging into the accumulator, which would represent the upper drum of a water-tube boiler, and conceive a cooler built substantially on the lines of a water-tube boiler, a brine cooler. That is, the brine passes through the tubes, and the ammonia boils on the outside, just as water boils on the outside of the return-flue boiler. If you would properly calculate the disengaging surface, you could hold your ammonia level at a point somewhat analogous to the level to which you would hold it in a return-flue boiler, giving approximately the same number of square feet of disengaging surface to the cubic foot of gas which you would expect to boil out, and, taking into consideration the pressure, you would reach a point where, no matter whether you fed all your liquid into the bottom of the boiler or fed it into the accumulator above, and boiled out this 17 or 18 per cent. which Mr. Rassbach speaks of, and then introduced it into the cooler at a cooler temperature, you would reach a point where if you had a sufficient number of feet of disengaging surface, which was adjusted to the cubic contents of the gas which you would expel from the cooler, you would have little or no projection of wet gas, and little or no return of liquid to your compressor.

I am simply stating this in the line of trying to get a little better conception of the matter before you. I am not attempting

to go into the commercial results, but I am simply trying to follow Mr. Rassbach's parallel between the action of ammonia in coils and steam boilers, and show that, after all is said and done, it is largely in the last analysis the amount of the disengaging surface at the end of your line, whether it be in the accumulator, or whether the accumulator be practically a part of the cooler. If it be a series of coils winding up into an accumulator, that accumulator has to be large enough to slow up the gas and permit the liquid to drop out, and it must have enough disengaging surface to boil out the gas necessary to reduce the "heat of the liquid" (from 15 to 20 per cent. of the whole) without priming.

Walter S. Ashton.—I wish to state in connection with the tanks I spoke of, that Mr. Pilsbry, something over a year ago, told me about a flooded system. I put one of them in. That was installed, as I said before, without any change in the tank. We took the liquid from the same source for each tank; we simply brought the pipe down from the liquid receiver, and branched it off to each tank.

President Block.—You did not precool it?

Walter S. Ashton.—There was no precooling. And the suction pipe was led into a common main. We operated three machines in that plant, and there is a common main to all three machines. Both suctions lead into the common main and, as I said before, we have the same amount of surface. We got those results, and it is due, as Mr. Rassbach said, to the fact that every foot of pipe in the flooded tank was active.

Another thing we discovered was that it is much less trouble for a man to handle a flooded system than it is to handle, say, 19 expansion valves. He could not handle those valves and get results. The returns led up and down in the header so that no liquid could return, and all the operator had to go by were the frost on the pipes and the temperature of the brine. He could see that those coils would frost when they were probably half of them active. It showed beyond any doubt that the flooded system makes every coil in the tank active in heat-absorption.

Otto Luhr.—I cannot see how the capacity of the ice tank would be increased materially, unless you would reduce the temperature of the brine or increase the circulation of the brine. I fully agree with Mr. Rassbach that, to make every foot of pipe effective you fill it with liquid, which is a better absorbent of heat than is gas. If you take a tank which is at its full capacity, say, for instance, a 50-ton plant, and you make 50 tons with a certain temperature of

the brine, and then turn that tank into a flooded system, and maintain the same temperature of the brine, I do not see how you can pull more ice out of that tank unless you increase the circulation of the brine or reduce the brine in temperature. That is the only way to do it.

Walter S. Ashton.—I will state, for Mr. Luhr's information, that the brine temperature was materially reduced.

H. Rassbach.—It is evident in the case which Mr. Ashton stated that if all coils are made effective from end to end, they will evaporate more liquid than before, and with the increased amount of liquid ammonia which is evaporated in those coils we increase the capacity of the plant, or reduce the temperature of the brine.

Victor H. Becker.—Unless you pull more ice.

William C. Bardenheuer.—If you feed through the expansion cock on an expansion system, the sensible heat of liquid will have to be taken out, partly by its own evaporation and partly by transmission from the surrounding brine, owing to the fact that the change from liquid into gaseous form is not a momentary one. The farther we get away from the feed end of the coil the less heat will be transmitted from the brine through the coils, owing to the comparatively dry inner surface of the pipes. In the flooded system heat is transmitted through coils equally on the entire coil surface, for the reason that transmission through iron pipes is more intense from one liquid to another than from gas to liquid.

President Block.—Plate or can?

William C. Bardenheuer.—Can; the brine was at 75 to 80 degrees Fahrenheit when the plant was started, and brought down to about 11 degrees in 36 hours, and it was occasionally carried as low as 8 degrees when the ice was pulled less regularly.

President Block.—Have you the same operating engineers that you had at first?

William C. Bardenheuer.—The same engineers.

Robert A. Whelan.—I wish to say that at two of our plants we have a modified form of the accumulator on our brine-cooler. We are doing good work. That is, we are expanding our ammonia from our receiver into our accumulator, and from there it is entering into our brine-cooler.

Some time ago a change of consulting engineers was made, and the man who took charge said the proper place for the expansion of the ammonia is right in the bottom of that brine-cooler. We were running our brine at a temperature of from 15 to 18 degrees minus. He stopped using that in one of the plants, and the consequence was

that the engineer was complaining all the time that he could not get the desired temperature. Over the objection of this consulting engineer, we returned to the old way, and our engineer soon satisfied everybody that he got the temperature. This was called an accumulator, and, as I understand it, part of the inner traps were taken out and our gas, returning, passed through it; we expanded down at the bottom, or toward the bottom, whereas our gas went through on the top.

President Block.—And then back to the compressor?

Robert A. Whelan.—Back to our absorber.

John E. Starr.—I am somewhat familiar with the instrument Mr. Whelan has referred to. This question of this accumulator and its reported action is a case exactly in point. The cylinder forming the accumulator on this machine, to the best of my recollection, was only 16 inches in diameter; it was upright, and intended for a 100-ton machine. Taking into consideration my previous statements, as to the relation of the disengaging surface to the number of cubic feet of ammonia to be evaporated, I do not think it would make any difference whether this accumulator was on there or not. It only had 1.4 square feet of disengaging surface and should have had 12 square feet.

Peter Neff.—Two or three plants have come under my observation. One was a plant in which the tank was already in existence. It contained 8,000 feet of one-inch pipe, and it was impossible to change that piping; it was therefore arranged to operate as a flooded system. It did very nicely, and produced on the average 42 or 43 tons of ice. It had never done so before. Whether that was due to the flooded system or not I do not know.

Another case was where the system was operated with coils connected with the headers, and the ammonia fed at the bottom, and it produced certain results. Comparing those results with the results of a plant in which the ordinary vertical-coil top-feed, with individual expansion valves, as used, it showed practically the identical number of feet of pipe surface to the ton of ice produced, allowing for the slight difference due to the fact that one had 60-degree and the other 80-degree cooling water.

President Block.—Which had 60 and which had 80-degree cooling water?

Peter Neff.—The one with the 80-degree water had bottom-feed; in that case you had to evaporate more ammonia; that is, you had more work to do in that tank than in the other. That was the only difference shown.

President Block.—In other words, both showed exactly the same results?

Peter Neff.—The same results.

President Block.—Of course, other things must be taken into consideration which you perhaps did not observe. The operation of such a plant by the men who handle it has a great deal to do with the results obtained.

Peter Neff.—There were the conditions, and there were the differences which I have stated, and they worked out as I have indicated.

H. Rassbach.—As far as an increase of capacity is concerned, I should like to give an experience of my own. Years ago I built a plate plant before I knew about the gravity-feed system. There were expansion valves, one for every three plates. I did my very best, but never succeeded in getting more than 42 tons of ice from that plant. Only two years ago this plant was changed and the gravity-feed system installed. The same machinery is there, the same number of coils and piping, the same condensers, and everything is the same now as it was then, but the plant turns out 67 tons of plate ice regularly.

President Block.—You might have had the same result if you had put on three times as many expansion valves.

H. Rassbach.—The great trouble was in the beginning that there was no possibility of regulating the supply of ammonia to each individual coil in the proper manner, and the *compressor* was half the time flooded with liquid.

President Block.—It was impossible to regulate the flow in the manner in which you attempted to do it, by having one expansion valve control the flow of liquid to three coils. If you had put three times the number of expansion valves in you might also have made 67 tons. Therefore, that experiment is of no value in this connection.

H. Rassbach.—The coils were all frosted through.

Walter S. Ashton.—For several years I was in charge of a plate-ice plant that had 240 direct-expansion plates or cells. These plates were piped up so that one, two, three or four plates could be controlled by one expansion valve. When the ice was thin we could control the expansion very well, but when the ice got thick we could not cramp the expansion valve down fine enough to prevent the liquid ammonia from going to the compressors and causing trouble. We experimented with the expansion valve and found that the more linear feet of expansion piping we had on one expansion valve the

less trouble we had in the liquid coming over to the compressors, but we could not get good results in the freezing of the ice; the plates nearest the expansion valve made thick ice, while those on the end of the run made ice that was not thick enough.

If we had known at that time about the "flooded system," with the separators to return the excess liquid ammonia to the expansion coils, we would have made a success of an expensive plant that finally proved a failure.

William C. Bardenheuer.—I would like to have Mr. Ashton state why he did not want to have an expansion valve in each individual coil.

Walter S. Ashton.—They were too short. With the number of feet of pipe in them, after your ice became old, you could not get those expansion valves down fine enough.

William C. Bardenheuer.—You did not have a good expansion valve?

Walter S. Ashton.—I do not believe there are any very good ones even now.

A. P. Criswell.—I was unfortunately detained and I did not get here while Mr. Rassbach's paper was being read, but in reading over my copy of his paper I notice that he refers to the Krebs system, and he says that some ten years afterward this system was taken up by another person. I should like to ask Mr. Rassbach whether that referred to his own investigation along that line, or to the investigation of some other person along the same line.

H. Rassbach.—I became interested in plate ice making in 1894, and for the first time used the gravity-feed system in its present form in 1898. It was then further developed by the Vilter Manufacturing Company, and when I was requested to take out Letters Patent my attention was called to the Krebs patent, in reply to my application by the patent examiner. To the best of my knowledge, however, the system as now designed, and as applied by me at the stated time, had never been used or known before.

After learning about the Krebs patent, I looked for a plant where I might see that system in practical operation, but failed to find one, or learn about one, and therefore I came to the conclusion that it had never been put into use to any extent.

In a publication about two years ago, and in this present paper, I admitted frankly that the first thought of this system, that the principal idea of it, was conceived by Johannes Krebs, but that his invention lacked one very essential feature without which it is unfit

for practical use, namely, the precooling of the liquid previous to its release from pressure.

In direct reply to Mr. Criswell's question, I would have to answer that the development and final success of this system is due to my own investigations and conclusions in this line.

William C. Bardenheuer.—I should like to ask one question: In the accumulator the surface of the liquid is exposed to the suction of the compressor. Why, then, should we have no back-freezing on the suction line toward the compressor? The reason I ask that is this, I have seen a dry-gas machine working wet. I have seen the pipes coming from the accumulator for about 80 to 100 feet very heavily frosted. Why should not the piping, after pumping the gas out of the accumulator, frost back to the machine, or as far as we want to? What is the reason we cannot run the machine dry, after it takes gas out of a vessel which contains liquid ammonia?

H. Rassbach.—If I understand Mr. Bardenheuer correctly, I might answer his question in this way: The accumulator, as mentioned before, is a vessel carefully protected from the influence of outside heat. The liquid ammonia contained in it does not evaporate and cannot evaporate as long as its temperature conforms to the pressure under which it is held and which in the regular operation of a plant is subject to but slight fluctuations. Any reduction of pressure by the action of the compressor will result in an evaporation of some of the liquid contained in the accumulator, for which some of the heat still contained in the liquid is consumed until an equilibrium is restored between the now reduced pressure and the correspondingly decreased temperature of the liquid. If we would evacuate the accumulator as much as the compressor permits, say to a vacuum of 27 or 28 inches, we could not get any liquid back to the compressor, and thereby cause any back-freezing, for the reason that the temperature of the liquid, which is contained in the accumulator, would gradually drop to less than 40 degrees below zero, or whatever the temperature corresponding with 27 inches of vacuum may be, and further evaporation would cease. It is doubtful whether the evaporation or ebullition of the liquid in pursuance of such a process would be so violent as to cause what we may call a priming of the accumulator. The fact of having the surface of the liquid in the accumulator directly exposed to the suction of the compressor cannot in itself produce a back-freezing to the latter, because the suction alone cannot remove a particle of this liquid without the aid of heat, which would first have to convert the liquid into gas, but which is excluded from the accumulator.

President Block.—You, of course, insulate the accumulator?

H. Rassbach.—Yes.

President Block.—Before we close this discussion I want to state that in 1892 Dr. Krebs came to the De La Vergne Machine Company and exhibited his patents, and wanted Mr. De La Vergne to purchase them. The De La Vergne Company at that time had a five-ton ice-freezing plant erected in a room adjoining its boiler-house. Mr. De LaVergne at once consented to try Dr. Krebs' system. An accumulator 15 inches in diameter and six feet high was erected in accordance with Dr. Krebs' directions; the gas return was in the center, and baffle-plates were placed between the center and the top of the accumulator tank. The liquid was fed from the bottom of the tank at a height of about three feet above the tank. The brine was circulated by a propeller, and temperatures were taken of the brine, first with the so-called direct-expansion system and afterward with the accumulator system. The number of cans remained the same, and a certain quantity of ice was frozen every 24 hours. The ice cakes were, I think, four inches thick, and were frozen in the course of 12 hours. We found that with Dr. Krebs' system we increased the heat transmission through the brine-cooling coils five per cent. We made five per cent. more ice than we did with the direct-expansion. We had a single-acting compressor, and did not dare to freeze back very far. Dr. Krebs seemed somewhat disappointed and said: "Now we will circulate liquid ammonia through these coils by means of a pump." We had on our premises an old aqua ammonia pump belonging to some absorption machine. We rigged that up and connected the suction of that pump to the lower head of the accumulator tank, and then pumped the ammonia through the evaporator coils in the brine-tank, and got an increase of 30 per cent. capacity out of the tank. The difficulties, however, of pumping the ammonia through—that is, the difficulties with the pump and the stuffing-boxes of the pump—were such that we did not care to go into it, and stated so to Dr. Krebs at the time.

Victor H. Becker.—Why didn't you add an additional compressor to that tank and thus determine its actual capacity?

President Block.—It was an 18-ton compressor, and a 5-ton tank. That was sufficient.

No. 71.

AUTOGENOUS WELDING.

By Fred W. Wolf, Jr., Chicago, Ill.

(*Member of the Society*)

Refrigerating engineers ought to be interested in autogenous welding, in view of the fact that every one of the prominent manufacturers of cooling apparatus has an oxygen-acetylene welding plant, and because the next few years will undoubtedly see considerable progress made and many methods of manufacture improved.

Welding with the blowpipe is rapidly superseding riveting, brazing, soldering, electric welding, and, in combination with pressed steel, is replacing difficult test castings. For example, this double pipe ammonia return bend is made of two drop forged halves welded together and then welded to the ammonia pipe, doing away with the threaded joint, so weak, liable to leak, and apt to corrode, which same objection might also be applied to pipe headers.

It has been proved by the makers of electrical transformers that welded tanks are far superior to riveted ones. It is a well-known fact that hot oil will seep through any seam, and it is not possible to make transformers of steel except by welding. Riveted street car air receivers did not remain tight, due to extraordinary service; now they are also being welded.

In locomotive and marine boilers cracks and defects in flue, crown and side sheets are being welded; even defective sheets are cut out with a blowpipe, which is being done at the rate of about a foot a minute, and patches are being welded in. What is being done on these high pressure boilers can very easily be done in stationary plants.

Defective castings can be made good by fusing in additional cast iron, and, because ferro-silicon rods are used and the weld kept covered by a flux, the repaired spot is not hard, and can readily be machined. The output of a shop, therefore, becomes more dependable, less labor and time are wasted machining worthless parts, and the necessity of making more pieces than are actually needed is done away with.

Every coil bender is equipped to repair splits, opened seams, pinholes, and other defects, burned spots, and defective electric

welds. It is also possible to repair defective pipe work in situation, thus saving the labor, time and cost of tearing out and replacing, which is a very considerable item in inaccessible locations. Especially is this true in reference to ice tank coils, condensers, expansion coils, etc.; welding a defect is as simple as soldering.

In Germany, welded ice molds, galvanized, are on the market. Ice tanks can be welded in situation, absorption machinery is being welded, condenser stands, in fact almost anything, can be made in quantities cheaper and better of welded pressed steel than cast; especially is this true in our field of engineering, where castings are not only heavy and costly, but hard to machine and undependable as well.

Autogenous welding is done without pressure by applying locally sufficient pure heat to bring about self-fusion between the old materials to be united and the filling substance by means of the oxy-acetylene blowpipe flame, the temperature of which is about 6000 degrees Fahr.

In every process of welding internal strains are inevitably set up. These are due to the fact that metal expands when heated and contracts when cooled, so that when two pieces of metal are welded together, locally, either by the simple fusion of their parts or with the addition of molten metal, contraction occurs as the metal cools. Where these parts form restrained members of any structure, the internal strains produced are often sufficient to crack the metal. This is more especially the case when welding is employed on hard, brittle or inelastic material, such as cast iron, and the tendency to fracture is greatly increased if the cooling of the metal, after welding, is conducted rapidly or irregularly. The magnitude of the forces that bring about this fracture in cast iron may be estimated by the rules for contraction which hold good in foundry practice, because in simple fusion-welding the physical conditions of expansion and contraction in and around the weld are not dissimilar to those of the foundry.

Whenever local strains exceed the strength of the metal a fracture must inevitably occur. This strain, however, often remains latent within the metal, so that the fracture may not actually take place until brought about by some external cause, such as a light blow or even a current of cold air.

The less brittle a metal naturally is, or, in other words, the more ductile it is, the better it is capable of withstanding internal strains of this description. The sudden cooling of any metallic body which has been welded should be scrupulously avoided.

In order to relieve a welded piece of metal from internal strains

due to welding, it is desirable not only to pre-heat the whole of the part when possible, but also to re-heat it after welding to a cherry-red heat. This causes molecular rearrangements to take place within the metal, which will bring about a distribution if not an actual dispersion of internal strains. In the case of cast iron, this treatment is imperative where a repair is affected in a restrained member of the structure, and not only should pre-heating and re-heating, or annealing, be always employed, but the raising and lowering of temperature in so doing should be slow, and the casting should be kept entirely free from air draughts or other extraneous cooling effects. This treatment is less essential for steel, but it never can be other than beneficial.

Unfortunately, for large work it is generally impossible to anneal the whole structure in this way. In such cases it is a useful makeshift to heat the plate for a considerable area around the weld, both before and after welding. It is obvious that the nearer the temperature of the whole structure can be brought to the fusion temperature required for a local repair, the less will be the excess of expansion at the welded point, and consequently the less will be the local strain set up at this point when the structure cools. Too much attention cannot be paid to this physical aspect of welding, and even when the process of fusion-welding is employed to fill up flaws in castings, it is desirable, when possible, to heat the whole structure before and after treatment.

The temperature of the flame in a good oxy-acetylene blowpipe is, approximately, 6000 degrees Fahr. This high temperature is mainly attained by the combustion of carbide-dioxide. The chemical combustion of acetylene and the physical conditions which arise during its combustion in oxygen differ essentially from those which occur in the case of hydrogen. Acetylene has a heating value of about 1500 B. t. u. per cubic foot. It is, approximately, composed of 92.5 per cent. carbon and 7.5 per cent. hydrogen, which in combustion with oxygen form carbon-dioxide and water. In consequence of the high flame temperature, however, the water formed by this primary combustion is disassociated into hydrogen and oxygen; the latter element combines at once in the flame with the carbon of the acetylene to form carbon-dioxide, while the hydrogen can only combine with oxygen which has passed out of the hottest zone of the flame, and thus does not involve a consumption of heat at the expense of the hottest part. It is, in fact, claimed for oxy-acetylene welding that the hydrogen forms a relatively cool jacket around the hot flame produced by the combustion of carbon in oxygen, and

that as the hydrogen is not able to combine with oxygen at the very high temperature which exists within the inner zone, but remains temporarily in a free state, it protects the inner zone, in a measure, from loss of heat, while largely excluding the tendency to oxidation of the metal,—a defect from which all other methods of welding suffer. With the oxy-acetylene flame it is even claimed that burnt or overheated metal is not likely to exist, because burnt metal, *i. e.*, metal which has combined with oxygen, is not stable at such high temperature, and must, therefore, be reduced to a metallic condition.

The strength of the weld produced by the flame is almost invariably somewhat less than that of the original material. This may be due to the use of welding strips of inferior tensile strength, or to those internal strains which have already been referred to. It is also undeniable that the structure of the material in the weld is less homogeneous than in other parts. This, however, is largely a matter of skill on the part of the individual welder. It is possible for a competent welder, at his own discretion, to give a greater or less strength to the welded part, and for this reason it is impossible to draw conclusions from the work of one man as to the work of another. Oxygen-acetylene welding must be regarded as a trade which can only be mastered by intelligent work and gradual development from simple to difficult jobs. Much depends upon the intelligence and ability of the welder. A skillful welder will use a hammer freely as well as a blowpipe, more especially on vertical or overhead welds in plates which are subsequently to be subjected to pressure strains. By the judicious use of hammering at the right moment on the welded part the metal can always be made denser, with the result that the strength of the weld is increased.

It has been stated that electric welding is more efficient and economical for most purposes than oxy-acetylene welding. This is, however, not strictly correct. The first cost of an electric welding apparatus is incomparably greater than that of an oxy-acetylene welding apparatus. It is also far less portable and its scope is consequently more restricted. There are certain applications for which electric welding may be more suitable, but for ordinary everyday work there can be no doubt that the oxy-acetylene system is much to be preferred, for the following reasons, apart from the question of cost:

In welding with the electric arc, heat must of necessity be concentrated upon one point, viz., that to which the temperature of the arc is imparted. In oxy-acetylene welding, on the other hand, the heat can be brought to bear at will on the surrounding material. The

correct welding heat can thus be gradually attained at any desired point. In electric welding any unsteadiness of the hand will at once strike the arc between the two carbon points, and will thus cause an addition of fused material to the bulk of the metal where it is not required. In the oxy-acetylene process, material can be gradually built up as desired exactly on the part to which the flame is directed. In electric welding, the arc is formed at the expense of atmospheric oxygen, and this fact indicates that chemical changes of an oxidizing character must take place in the welded part. In oxy-acetylene welding, as already stated, the welded part is surrounded by a shield of hydrogen, which tends to isolate atmospheric oxygen from the part being welded. In electric welding, a fairly stout iron wire must of necessity be used to serve as a pole of the electric arc, whereas, in oxy-acetylene welding thin wires can be employed, and these are found by experience to be most suitable for the work. In electric welding the size of the drop of fused metal added in building up the weld is not within the control of the welder to anything like the extent it is in the case of the oxy-acetylene welder. Finally, and this is perhaps the most important point of all, in electric welding any subsequent treatment of the welded place, such as a gradual annealing of the area surrounding the weld, is impossible. In oxy-acetylene welding, this can be done with ease, and, as already pointed out, it is just this subsequent treatment of the welded part, with a view to removing internal strains and depriving the weld of its hard and brittle character, which forms the special merit of oxy-acetylene welding in large apparatus where homogeneity of the metal is a matter of the utmost importance.

During the last few years oxygen has come very prominently into use for the purpose of cutting wrought iron and steel plates and structures of all sorts. The process is based on the well-known fact that a jet of oxygen directed upon a previously heated spot of metal ignites it, with the result that the metal, acting as its own fuel, burns away rapidly in the form of iron oxide.

The appliances used for this work are of various designs but are identical in principle. They all consist essentially of a blowpipe with an additional passage through which an independent and separately controlled stream of oxygen is supplied at the discretion of the operator. This separate supply of oxygen may be conveyed through the center of the blowpipe, in which case the mixed gases employed for heating are conducted through an annulus surrounding it, or the supply may be brought in a passage immediately behind the heating flame. There does not appear to be much to choose between these ar-

rangements. The object of each is to pre-heat to incandescence the spot on which the jet of oxygen is afterward caused to impinge and then to maintain that heat while the oxygen jet is operating on the metal.

Strictly speaking, once the metal is ignited and the jet in operation, an auxiliary source of heat ought not to be required. It is, however, found difficult in practice to maintain with certainty the combustion of metal in the oxygen jet owing to unsteadiness in manipulation on the part of the operator, and to particles of oxide striking and momentarily blocking the orifice of the jet. This difficulty is overcome by the simple expedient of maintaining the heat jet in operation while the cutter is traveling, so that it is always available for the supply of the necessary heat to ensure continuous combustion of the metal in the stream of oxygen.

The cutting operation is very simple and can be mastered by any intelligent workman in a few hours. The edge of the surface of the plate at the point to be cut is first heated by the mixed jet of oxygen and any suitable combustible gas. When this spot has been wrought to a state of incandescence, a fine cutting jet of oxygen is discharged upon it. This immediately produces combustion of the metal with the resulting formation of iron oxide. The jet of oxygen is made sufficiently strong to blow away this iron oxide in front of it, with the result that a clean, narrow cut is effected through the metal at a speed of travel which is comparable with hot sawing. The metal on each side of the cut is neither melted nor injured in any way, as the action proceeds too rapidly for the heat to spread; in fact, the edges present the sharp and purely metallic surface of a saw cut.

The cutting may be made to follow any desired line, executing circles, curves, or profiles as desired, for which purpose guides and other accessories are usually provided, or can be readily constructed. Bevel cuts can be made and the process can be employed for the cutting of all grades of steel, as the action being chemical rather than mechanical, the quality of the metal does not materially affect the results.

For cutting away defective parts in boiler furnaces prior to welding, or for cutting out the furnaces altogether, this process is invaluable and is constantly employed; in fact, its applications are unlimited, as it is a handy, portable tool for which, unlike the blowpipe, no prolonged special training is required.

Cutters are now for the most part constructed to work optionally with coal-gas or acetylene as the combustible gas for heating. For new or clean metal, coal-gas will be found preferable both from

the point of view of economy and quality of work. On the other hand, for the cutting of all scaled, oxidized, or inaccessible structures, the superior heat of the oxy-acetylene flame will be found to greatly facilitate and quicken the work done by the cutter.

In addition to the hand apparatus, special machines are on the market for cutting pipes, circles, ellipses for manholes in boilers, and other shapes common in engineering experience.

There are also special appliances in use for ensuring a steady movement of the cutting nozzle, a matter of considerable importance where neat and accurate work is desired. In fact, new appliances are constantly being devised with the object of extending the application of the process and of improving the results obtained.

The process may be employed for cutting sections of any thickness up to and exceeding eight inches. Most cutters can be employed without any structural alteration on plates varying in thickness within wide limits—all that is necessary is to increase the velocity and quantity of oxygen used for cutting to correspond with the increased thickness of the plate.

The efficiency of oxygen cutting appliances now on the market varies within wide limits, and different workmen by no means obtain similar results with the same cutter.

A welding plant primarily consists of a cylinder of compressed oxygen to which is fitted a diaphragm reducing valve which can be adjusted to maintain constantly the working pressure of the particular torch in use. To this constant pressure regulator the torch is connected by means of hose or pipe, which may be of any length, about like a pneumatic tool. From the torch another connection is made to the source of acetylene, which may be either a tank of dissolved acetylene or an acetylene generator.

There are all told about 400 plants in successful operation in the factories of manufacturers in this country.

To recapitulate, permit me to emphasize the value of this process of manufacturing ice making and refrigerating apparatus; to again call your attention to the possibility of making ammonia fittings and parts of pressed steel members welded together; also to the fact that header tees, ice molds, brine tanks, condenser stands, drip troughs, submerged condensers, and absorption apparatus can be made better than at present; also that defective castings can be made tight: in fact, castings difficult to mold as a whole can be made in parts and welded.

No. 72.

COLD STORAGE TEMPERATURES AND ARRANGEMENT OF COLD STORAGE WAREHOUSES FOR HANDLING ALL CLASSES OF MERCHANDISE.

By Walter L. Hill, Boston, Mass.

(Associate Member of the Society.)

The merchandise usually put into cold storage may be placed in two classes—frozen and non-frozen. Most merchandise to be frozen contains more or less oil. In order to retain the quality the heat should be extracted as quickly as possible and the merchandise held at a temperature that will freeze the oil. It has been my experience that if goods are quickly frozen, and held in a temperature of from —10 degrees to +10 degrees Fahr., good results will be obtained.

This leads to the question of piping and insulation. Good insulation is a good investment for the warehouseman. In order to quickly absorb the heat from merchandise it is necessary to have sufficient piping or heat-absorbing surface. An element which enters into this to a large extent is the method of packing merchandise. Poultry, butter, etc., are usually packed in well insulated packages, making it difficult to get at the heat in the merchandise. Another element is the quantity brought to the warehouse to be frozen, as the greatest amount is brought at a time when conditions for freezing are most unfavorable. For these reasons, I recommend heavily piped rooms.

A great deal of the criticism of goods taken from cold storage is due to the improper condition they are in when brought to the warehouse, and is not due to the fact that the goods have been in cold storage. In a properly piped house, the condition of the goods when taken out should be very nearly what it was when they were put in.

The intelligent storers of meats to-day realize that in order to get goods out of cold storage in good order, they must go in in good order.

The non-frozen merchandise is greater in variety and more difficult to handle, as the range in temperature at which it is held is an important factor, due to the fact that constant deterioration is taking place.

The point in handling this kind of merchandise is to at once bring the temperature to as near the freezing point as possible, and retain that temperature. Fluctuating temperatures materially injure the goods. Eggs, which are the most important staple in the non-frozen class, may be carried at a little under the freezing point of water without freezing. The room in which apples are stored can be carried as low as 27 degrees Fahr. while the apples are coming in, without danger of freezing. This is due to the insulation which the wood of the barrel furnishes. Oranges, grape fruit, and lemons are more sensitive to temperature than northern raised fruits. Apples and pears may be kept in a room without danger at a temperature at which grape fruit, etc., would show discoloration on the skin.

There are a variety of goods that do not require a 32-degree temperature, but, as a rule, the non-frozen merchandise will show best results if carried at or near the point of freezing. There are several exceptions to this rule, one of which is chocolate confections, put in cold storage for the purpose of holding the chocolate covering hard, which, if held at too low a temperature, will accumulate moisture on coming out and injure the appearance of the goods.

Care should be taken in putting warm goods into a room with goods already cooled, as the bringing in of warm goods will affect those already there.

I believe rooms that are piped for direct expansion should have at least two expansions, and while the rooms are being filled or when new goods are coming in, the expansion should be handled so as to take up quickly the added heat units.

For the construction and arrangement of a warehouse for the handling of all classes of merchandise, I, personally, believe in brick, with careful consideration for insulation and fireproof qualities. I designed the warehouse of the Worcester Cold Storage & Warehouse Co., Worcester, Mass., and the elements considered were economy of construction, ease of insulation and fireproof conditions. This house is built of brick, six stories high. On the ground floor are two stores, receiving and delivery rooms. The floor above this is fire-proof. Above the first floor is improved mill construction with no openings, except the elevator and stairway, which are fire-proof. To explain it simply, we have for the warehouse a brick box with wooden shelves in it. The building is 85 x 85 feet, each floor being divided into three rooms, two small and one large. This building, while not what is considered strictly fire-proof, is so constructed that we get a very low rate of insurance. The upper floors are heavily piped, the two lower floors not as heavily.

We carry the frozen merchandise on the top floors, and the non-frozen on the lower floors, thus utilizing any benefits which may come from radiation. If a house is properly arranged and piped, I do not think it is necessary to have separate houses for different kinds of merchandise, as the business success of a house is based on the utilization of space at the lowest cost, both in handling the merchandise and use of power.

DISCUSSION.

President Block.—I should like you to explain a little more fully what you mean, Mr. Hill, by "heavy piping." You speak of a heavily-piped room.

Walter L. Hill.—In the house which I described, the upper floors are piped about 1 to 10 and the lower floors are piped about 1 to 6.

President Block.—But that does not give any clear idea as to what you mean by heavy piping. Do you pipe your rooms sufficiently to turn the entire house into a freezing-room?

Walter L. Hill.—Yes; you could if the goods came in slowly enough; not too many at once. Any room could be made a freezing-room in that house; but if large quantities came in and were put into the room piped 1 to 10 you would have to be careful in putting them in so as to hold the temperature uniform.

President Block.—The usual custom is to have two kinds of rooms in a cold storage warehouse, one called the freezing rooms and the others called the 32-degree rooms.

Walter L. Hill.—Yes; I think that is true in a great many instances.

President Block.—I want to know, since you mentioned heavily-piped rooms, whether those were the same, or whether they differ from the other rooms in the house.

Walter L. Hill.—In the Eastern cold storage warehouses one house was piped by the De La Vergne Company 1 to 10 to 12. We built another house about as large and piped it ourselves. I think that house was piped about 1 to 6. These latter rooms are all available at any time for any kind of merchandise. It does not matter in what quantities the goods are put in. I wind up my paper by saying that the business success of a house is due to the utilization of space at the least cost of power. It may cost a little more in the installation of a plant to put in a little extra piping or increased compressor capacity, but I want to assure you that in the end it is money well spent.

Robert A. Whelan.—In regard to heavily piped rooms, the inference I draw from what has been said is this—that you pipe your rooms heavily enough to maintain a cold temperature while putting in the goods. In other words, if a room is being filled with poultry your rooms are piped very heavily, so as to maintain a low temperature while those rooms are being filled, assuming you have two or three rooms that you use for the storage of poultry.

Walter L. Hill.—We use almost any room for that.

Robert A. Whelan.—I was using this as an illustration, that in order to cool this room down quickly you can throw on, instead of 10 tons of refrigeration which would ordinarily maintain that room, 30 tons, leaving the other two rooms without any circulation. In other words, you could throw excess power in there while filling it and first freezing the goods, and after they are frozen this excess refrigeration may be turned off. Is that the idea?

Walter L. Hill.—The paper covers that point by saying that a house, while being piped, should be piped heavily, and that while fresh goods are going into a room that has already been refrigerated, the second expansion should be used, if it only had two. In a great many rooms four are put in. The second expansion will hold the temperature while new goods are being put in.

Roderick H. Tait.—In arranging a house to make any room a freezer, suppose, for instance, you have floors numbered 1, 2, 3, 4 and 5, and you wanted to make No. 3 a freezer, do you insulate every floor in the building?

Walter L. Hill.—Yes.

Roderick H. Tait.—In doing that do you experience difficulty in preventing goods on the floor above from being frozen, goods that you do not want to have frozen?

Walter L. Hill.—By the transmission through the floor of the cold, do you mean?

Roderick H. Tait.—Yes.

Walter L. Hill.—No; the insulation between the floors is sufficient to take care of that.

Roderick H. Tait.—How much insulation do you put in a floor between the freezers and a room containing goods not to be frozen?

Walter L. Hill.—The form of construction which we employ between the floors is such that we have never had any trouble, although I cannot state exactly what it is. I believe all houses should be built with floor insulation, for the reason that any part of it may be used, and it will not be necessary to refrigerate the portion which is not used.

Roderick H. Tait.—Have you ever found it necessary to have circulation in the room under or over the freezer, to prevent goods from freezing? On the floor above the freezing room, for instance?

Walter L. Hill.—We do not carry our goods on the floor. They are raised from the floor.

Roderick H. Tait.—But even then, I ask you if you have ever had trouble with the floor over the freezer?

Walter L. Hill.—I never have. That is due to the insulation between the floors. The floors are so arranged that they will not leak. You will not lose your refrigeration.

Robert A. Whelan.—In our Chicago house we have a mill-constructed building. For insulation between the freezer floors and the other floors there are 16 inches of mill shavings. In the freezer room the ceiling is of two thicknesses of matched boards, and on the floor above there are pieces 3 by 6, with paper in between, and maple flooring over that. After we had been operating there for a year or so we began to experience the trouble that Mr. Tait was inquiring about; in other words, we found that the leakage through from the low-temperature rooms into the high-temperature rooms was so great that goods piled close to the floor on the dunnage were affected by the leakage through the insulation.

Walter L. Hill.—That would unquestionably be so if you got any moisture into the shavings.

President Block.—I have seen that trouble of which Mr. Tait speaks; with 4 inches of cork insulation in the ceiling, apples froze on the floor above.

Roderick H. Tait.—I want to say in that connection that we are at present laying out a house which, when completed, will be in four buildings, which are numbered 1, 2, 3 and 4. The two center houses are designed to be freezers, and part of the end houses are so built and piped as to make freezers of them. The two top floors of the outside house, No. 1, have not been arranged so as ever to be freezers. The ceiling of the freezer floor has been insulated, but I depend very largely upon the circulation in the top rooms to prevent freezing. I had imagined that that would very largely overcome the trouble which we would otherwise expect.

No. 73.

COMPARATIVE VALUE OF DIRECT AND INDIRECT REFRIGERATION FOR COLD STORAGE PLANTS.

By Nelson J. Waite, Cleveland, Ohio

(Member of the Society.)

In the preservation of perishable food products through the agency of refrigeration the distribution of the refrigerating medium has presented a problem to the refrigerating engineer second only in importance to the proper insulating of structures designed for that purpose. It was demonstrated very early in the development of the industry that the successful storing of food products was as fully dependent upon the dryness of the air within the rooms as upon the temperatures carried, and this problem of moisture is of such an intricate nature that at the present day we do not know the proper humidity required for a majority of the products stored.

This naturally has brought about the trial of various methods of cooling with varying degrees of success until practically all except the plan of placing the piping within the room to be cooled, or the forced circulation of air cooled in a separate chamber, have been abandoned, chiefly on account of their complicated nature and, therefore, difficulty of application, or waste of space.

In the larger houses refrigerated by the direct system, nothing but a simple arrangement of coils for the circulation of either brine or ammonia is considered necessary, the use of deflecting shields, false ceilings and the like having been abandoned principally on account of the difficulty of keeping them clean and the lodging of moisture. Where the piping is placed directly in the rooms it is of small moment whether brine circulation or direct expansion is employed, in so far as the preservation of the goods is concerned.

The ammonia system offers the most simple means of cooling, as it does not require any auxiliary equipment.

Objection has been raised by some who would otherwise prefer this method, to the danger of ammonia leakage and consequent damage to goods; no apprehension need be felt on this score if the proper fittings are used and the work of installing done in a thorough manner, as there are records of many years with this system in continuous use without loss.

With any system of refrigeration due consideration must be given to two points of the highest importance to the warehouseman, viz., the maintaining of a uniform temperature throughout the room and the prevention of the collection of moisture or anything that will propagate the growth of fungus or mold on any part of the room or the goods stored. To accomplish this necessitates a movement of the air so that the moisture it contains, together with the exhalation of the goods, be brought in contact with and collected by the cooling surfaces. The question has been raised as to the sufficiency of air circulation in a piped room for a long carry. This is extremely difficult of proof, as there are contributing factors met with in practice that vary the results; the location of the piping, the manner of piling or tiering the goods, the height of the tiers, and the method of handling the refrigerating medium, all have a bearing on the result. The air nearest the piping being of a lower temperature and, therefore, of greater specific gravity, naturally seeks the lowest point, thereby displacing the air of higher temperature, causing it to rise. This would seem to dictate the uniform distribution of the piped surface on the ceiling, which for economic reasons would be the proper place were it not for the fact that very little difference in temperature exists between the two points, and, as we are dependent upon gravitation due to this difference, a room piled solidly with various sizes and shapes of packages offers considerable resistance.

The size and shape of a room have some bearing on the most suitable method of piping; placing on the side walls as near the ceiling as possible gives better results for all medium temperature rooms; in small rooms the conditions are nearly uniform; in rooms over twenty-five feet in width a ceiling coil in addition to the side piping gives better results; in rooms of greater width two or more such coils may be necessary. Ceiling coils, in addition to promoting the circulation, attract any moisture that tends to collect on the ceiling of the room. In filling a room with goods, especially those intended to remain an entire season, due consideration must be given to nature's laws, as the movement of air whose circulation is due to gravity is such that a slight obstruction will so retard or deflect it that the result will be the opposite of that desired.

In rooms with wall piping, carried at medium temperatures, some space must be left between the piping and the packages to prevent the contents freezing, and this space should be kept clear from floor to ceiling, as it forms an important air channel; there must also be space enough between the top layer of goods and the ceiling for the free circulation of air; one or more aisles are always necessary

for the trucking of goods, above which forms a most suitable place for the ceiling coils without loss of space and also provides another channel.

A separation of the different owners' goods necessitates narrow cross aisles to provide access to the various lots, and where they are received in less than carload quantities a considerable number are unavoidable; it is also customary to raise the packages from two to four inches off the floor, and to use spacing strips between the layers. Tiering the goods in this way tends to separate the air currents and facilitates the circulation.

To maintain uniform room temperatures and proper humidity during the summer months after the rooms are filled is not a difficult matter, where the pipe surfaces are maintained in a dry state. At the approach of winter, however, care must be exercised in handling the refrigerant to prevent the accumulated frost from becoming a wet, soggy mass, raising the humidity at a time when the conditions of the goods are least favorable. If the ammonia system is in use it is better to run under a higher back-pressure than to attempt to regulate the expansion valves from day to day, as raising or lowering the temperature of the refrigerant in harmony with the atmospheric changes keeps the cooling surface in the same relative condition and automatically adjusts the conditions governing the circulation of the air within the room.

The above conditions refer to rooms carried at 30 degrees and above; freezing rooms do not demand the same attention in regard to air circulation, as the air contains very little moisture at the temperatures carried. Where sufficient space is carried at low temperatures, for both reasons of economy and flexibility in handling, it is necessary to operate under two different back-pressures, or two separate brine circuits, as this permits altering the temperature of the refrigerant for the benefit of the high temperature rooms and does not disturb the conditions in the low at a time, where large quantities of poultry or meats are stored, when the requirements are reversed. Some provision must be made for the ventilation of rooms, as there are gases exhaled from the goods, together with the odor of the different packing materials used, that are non-absorbable, and, if allowed to accumulate, cause results that are attributed to defective air circulation when the real trouble is directly traceable to the neglect of this important feature.

The introduction of outside air through doors or windows is absurd during the summer months and questionable at any time in cities, even when the temperature and moisture conditions are favor-

able, and, as warehouses are now being constructed without windows or wall openings of any kind, a ventilating system is imperative.

The indirect refrigeration of large cold storage warehouses is limited to the bunker room plan or its modifications, as any other mode is too wasteful of space. Chloride of calcium plays an important part with this system, and it is fortunate that we have a substance so well adapted to the requirements of cold storage work and which yet, in itself, is neither offensive nor detrimental to the apparatus. Considerably less pipe surface is required for a given space, and the circulation of calcium brine over the cooling coils maintains their efficiency at the highest point, at the same time absorbing the moisture and odors by direct contact with the air in circulation. Probably the most efficient apparatus for this purpose is constructed on the plan of a water cooling tower where separately cooled brine is spread over the surfaces in a thin film and the air circulated in the usual manner, either plan requiring the continuous operation of fans located in the warehouse.

The uniform distribution of the air is just as important with this system as the distribution of the pipe surface in the direct. Distributing and collecting ducts, covering the entire length of the room, are essential. The proper location for the inlet duct would be upon or near the floor, permitting a flow of air up and through the goods to the return or suction duct on the ceiling; but as this is impracticable they are attached to the ceiling with openings at proper intervals, provided with means for adjusting the flow of air.

One of the objections raised against this system is that the goods stored show greater shrinkage, which has been charged to the high velocity of the air currents. There is no doubt that this will occur if such is the case, or the air is permitted to strike directly on the goods. However, any trouble of this nature experienced is more likely to be caused by the extreme dryness of the air, due to its constant circulation in contact with calcium brine, which reduces the humidity to a point where evaporation of the goods is hastened, and we have the opposite extreme to contend with which this system was designed to overcome.

This appears simple to correct and to maintain just the proper degree of humidity, but here we encounter the fact that at present we have no reliable instrument that can be placed in the room to manifest this state at temperatures below 32 degrees, and it is unfortunate that at a temperature at which the most delicate product we have to handle is carried the stationary psychrometer is inoperative; the sling instrument will indicate properly at egg room temperature;

still, the taking of the requisite number of readings becomes a task and very few men employed about a warehouse are competent to take readings that can be relied upon.

The indirect system does not offer the same flexibility as the direct regarding the variety of commodities that may be safely stored, and in event of a short crop or a curtailed production of one product, where, later, an abundance of another of an entirely different nature and odor is offered, there is a possibility of some space remaining vacant due to the inability of the warehouseman to accept other goods on account of the idle space being on the same air circuit with goods that will not stand mixing.

A combination of both the direct and indirect systems can be employed to advantage, particularly in a house carrying a great variety of products, the air circulating system being used as an auxiliary to remove the gases and odors and regulate the humidity in the various rooms, independently, without fear of contamination, also to accelerate the freezing of goods received in large quantities, or those that have been exposed to adverse atmospheric conditions.

The generation of gases by cold storage products is not so rapid at temperatures in which they are held as to necessitate the constant circulation of air for their removal, and the presence of a distinguishable aroma is neither deleterious nor destructive.

A recent occurrence has demonstrated the increased fire and smoke hazard with the indirect system, if not properly safeguarded, even in fireproof buildings equipped with automatic sprinklers, and emphasizes the absolute necessity of the air-duct dampers and fan motors being placed under thermostatic control, so that, in the event of fire, circulation will cease, as the belated action of the sprinkler heads in the case referred to was unquestionably caused by the retarding influence of the air current.

DISCUSSION.

Daniel L. Holden.—I should like to ask Mr. Waite if he ever tried a brine-spray system in a cold storage room?

Nelson J. Waite.—The open brine system, do you mean?

Daniel L. Holden.—Yes.

Nelson J. Waite.—I have never tried it myself, but from what I have learned from the efforts of others it also shows a very high evaporation of the goods in the room. In fact, any open brine system will have that effect.

Daniel L. Holden.—Yes; it will absorb all the gases in the room.

It will dry the floors and the walls so that you can strike a match on them. You have to look out for that; regenerate the air.

Madison Cooper.—In general I am very much in accord with Mr. Waite's paper. I believe the points he has made are correct. There is one thing, however, that I think he has overlooked, or, at least, has not stated correctly as I see it, and that is the statement he made about the insurance factor. We put each room on a separate circulating system and it does not affect the insurance rate at all. That is a very important point.

Nelson J. Waite.—The case mentioned was a separate room.

Madison Cooper.—A separate room with a separate circulating system?

Nelson J. Waite.—Just one room cooled by an individual fan.

Madison Cooper.—The coil system was at some distance from the room?

Nelson J. Waite.—It was just outside. There was $500,000 damage done in twenty-five minutes to the contents, with only $3,000 damage to the building. It was reported by the insurance inspectors who made the survey that the excessive loss was due entirely to the inaction of the sprinkler heads, caused by the cooling of the air. There were 97 sprinkler heads in the room, and 78 of them operated at one time, showing that action was delayed, caused by the cooling effect of the circulating air. The insurance people are, as I understand it, right now looking into this very closely, in houses where they have the air-circulating system.

John E. Starr.—In regard to this question of the fire and smoke risk in the circulating air, the statements which Mr. Waite has made are very good; but I wish further to state that circulating-air systems are now installed where fireproof dampers are arranged and connected with thermostatic devices, so that these doors will automatically close when the temperature of the room rises above—if the room is to be held at a temperature of 32—say about 40, and these appliances have been approved by the National Board of Fire Underwriters, and considered by them as doing away with the danger which they had previously considered to exist.

Conrad H. Young.—Insurance people are also objecting seriously to allowing a continuous air conduit to go through adjoining rooms, where there are dividing partitions, thus making it necessary to chop them off. One of their schemes now is to have ducts run through some sort of an outside corridor, and then have the ducts go into each room direct from the outside.

No. 74.

COST OF MAKING ICE.

By A. P. Criswell, Chicago, Ill.
(Member of the Society)

It is impossible to estimate, even approximately, on the cost of operating any kind or size of ice plant anywhere without accurate knowledge of the local conditions under which the plant is to be operated. All of the several items that go to make up the cost of operation—labor, fuel, water, oil, waste and incidentals, ammonia, salt, depreciation and repairs, insurance and taxes and interest on the investment—have different values in different localities.

Labor estimates that would seem very high in small towns would be considered low in large cities. Coal is obtainable in many localities at a cost of $1 to $1.50 per ton, while in others it costs from $3 to $4 per ton, and in some foreign countries $10 and upwards.

Water can generally be had for the pumping, but in some instances the cost of this item alone, particularly where no cooling tower is used, may add from 40 cents to 50 cents per ton to the cost of making ice. Even at the price figured in the table (5 cents per 1,000 gallons) the cost of water will be 25 cents per ton of ice if no effort is made to save it; but it is presumed that no one will be so stupid as to operate an ice-making plant without a cooling tower, where water must be paid for, and these estimates are based accordingly on using the water over and over for cooling purposes, allowing 20 per cent. of the total amount for loss—by evaporation, waste and water actually used for making ice—and this is amply sufficient to cover all necessary losses, provided water can be recovered from the cooling tower at a temperature not to exceed 70 degrees to 80 degrees Fahr. In winter the amount of water may sometimes be reduced by 50 per cent. or more, and in very hot climates the amount required may be doubled.

Oil, waste and engine-room supplies will vary only slightly in cost for different cities. Anhydrous ammonia costs from 25 cents to 30 cents per pound in large cities of the United States, while this cost may be more than doubled in some foreign countries. Salt varies considerably in cost and quality, ranging from $3 to $10 per ton; but it will be seen that this item does not enter largely into the cost of ice, the quantity actually used being comparatively small.

APPROXIMATE COST OF MAKING ICE WITH PLANTS OF DIFFERENT SIZES OPERATING UNDER SIMILAR CONDITIONS.

(Table is figured in cents.)

Ice in Tons per Day of 24 Hours.	5	10	15	20	25	30	35	40	50	60	70	80	90	100	110	120
Engineer, day	210	230	250	270	290	310	330	350	390	415	440	465	490	515	540	565
Engineer, night	200	210	220	230	240	250	260	270	290	305	320	335	350	365	380	395
Tankman, day	.....	150	160	165	175	190	190	210	220	250	(2)380	400	420	440	460	480
Tankman, night	.....	.....	150	160	170	190	190	210	220	250	(2)380	400	420	440	460	480
Fireman, day	.....	.....	.....	175	175	190	195	205	225	250	250	250	275	300	300	300
Fireman, night	.....	.....	.....	.....	175	190	190	205	225	250	250	250	275	300	300	300
Laborer, day	.....	.....	.....	.....	.....	.....	150	150	165	175	175	175	200	200	200	200
Laborer, night	.....	.....	.....	.....	.....	.....	.....	.....	165	175	175	175	175	200	200	200
Oiler, day	.....	.....	.....	.....	.....	.....	.....	.....	.....	150	150	175	195	220	220	220
Oiler, night	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	175	195	220	220	220
Extra man, day	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	240	240
Extra man, night	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	240
Fuel, coal @ $2.50 per ton	250	500	750	1000	1250	1500	1750	2000	2500	3000	3500	4000	4500	5000	5500	6000
Water, @ 5c. per 1000 gals. (20% off)	25	50	75	100	125	150	175	200	250	300	350	400	450	500	550	600
Ammonia, @ 30c. per pound	25	50	75	100	125	150	175	200	250	300	350	400	450	500	550	600
Salt, @ $5.00 per ton	5	10	15	20	25	30	35	40	50	60	70	80	90	100	110	120
Oil, all kinds	5	10	15	20	25	30	35	40	50	60	70	80	90	100	110	120
Sundries, waste, etc.	5	10	15	20	25	30	35	40	50	60	70	80	90	100	110	120
Depreciation and repairs	50	100	150	200	250	300	350	400	500	600	700	800	900	1000	1100	1200
Insurance and taxes	50	100	150	200	250	300	350	400	500	600	700	800	900	1000	1100	1200
Interest	100	160	225	300	375	450	525	600	750	900	1050	1200	1350	1500	1650	1800
Cost, per day—total	925	1580	2250	2960	3675	4260	4935	5520	6800	8100	9380	10640	11790	13000	14300	15600
Cost per ton—total	185	158	150	148	147	142	141	138	136	135	134	133	131	130	130	130

Note.—It is presumed that cooling tower, saving 80 per cent. of the water required for cooling purposes, will be used where water is bought.

Depreciation and repairs will depend principally on the kind and cost of buildings and plant and on the care taken of them. Insurance and taxes will vary considerably, and will depend on the cost of buildings and plant, and on the cost of site as well. Interest on the investment is figured on the basis of average conditions prevailing in the towns and cities of the United States, and the fact that small plants are generally wanted only in small towns, where land and labor are cheap, and large ones in large cities, where land and labor are expensive, has been carefully considered.

For convenience, the interest has been figured at 5 per cent. for 360 days, so that it is necessary only to multiply the interest item by 360 and this product by 20 to arrive at the estimated cost of any given plant. Or, as 360 by 20 = 7,200, multiply the interest item by 7,200 and cut off two ciphers. The result will give the estimated cost of the plant in even dollars. For instance, the interest per day on a 5-ton plant is $1. This, multiplied by 7,200, gives $7,200 as the approximate cost of the plant, with buildings and site, in a small town. The interest on a 120-ton plant is $18. This, multiplied by 7,200, equals $129,600, approximate cost of the plant in a large city.

I desire to make it perfectly clear that this table is intended to show, approximately, the average costs of making ice in average can plants when operated at normal capacities under the conditions named.

My object in presenting this paper is to call attention to the single item where we may hope for improvement. A study of the table shows that the average cost per ton of all labor is about 36 cents; the cost of fuel 50 cents; water 5 cents; ammonia 5 cents; salt 1 cent; oil 1 cent; sundries, waste, etc., 1 cent; depreciation and repairs 10 cents; insurance and taxes 10 cents, and interest on the investment 15 cents. We can hope for very little reduction in the labor account. The other items, with the single exception of fuel, are practically constant, and no material reduction can be made in any of them. I believe it is easily within the range of possibilities to reduce the fuel expense by 50 per cent. by the use of high-class boilers and engines, mechanical stokers, fuel economizers, water purifiers and smoke consumers, provided the purchaser is willing to pay the price for a strictly first-class plant. Where water conditions are favorable the plate system, or, better, a combination of the plate and can system, is, in my opinion, advisable, the combination plant being so proportioned that the steam required to operate both systems will furnish the necessary distilled water for the can system and no more. This would add, perhaps, one-third to the cost of the installation,

thus raising the interest account by 5 cents per ton, leaving a net gain of 20 cents per ton, or about 15 per cent.

I have been requested to give the additional cost per ton when the plant is operated only six months per year, or 180 days running time. In answer, I will say that the table is arranged so that anyone may figure the cost of making ice for any given time. When the plant is shut down, practically all of the expenses may be cut out, with the exception of the last three items—depreciation and repairs, insurance and taxes and interest on the investment. The first of these is estimated to cover the necessary repairs to keep the plant in first-class condition always, and if the chief engineer and one or more of his assistants are retained during the time the plant is shut down their salaries may be charged against depreciation and repairs account, as the work they do will cut down that item accordingly. But these three items must be figured for the entire year, and this amount for the time of shutdown must be added to the expense while running and the total amount divided by the tons of ice made to get the total cost per ton for the entire year. Even in the case of a plant running only half the time the result is not so alarming as, at first thought, it seems; but we cannot get away from the fact that it adds to the cost about 35 cents per ton of ice made. Take, for instance, the 100-ton plant; the total cost per day is $130, or $23,400 for 180 days; the cost for the last three items is $35 per day, or $6,300 for 180 days, a total of $29,700 for 360 days, while the total output is 100 tons for 180 days, or 18,000 tons, equal to $1.65 per ton.

In this connection I wish to warn the trade against a certain class of fakers and dreamers who bob up from time to time with so-called "new processes," by which they claim to be able to make merchantable ice at a cost of 50 cents per ton. These claims will not bear the test of expert investigation, and nine times out of ten it will be found that the inventors are more anxious to sell stock in their get-rich-quick schemes than to put their inventions to a practical test.

DISCUSSION.

Fred W. Wolf, Jr.—I should like to criticise the use of Mr. Criswell's method of getting at the cost of the equipment. There is a variable he has not taken into consideration. He compares the cost of a small plant in a small town with the cost of a large plant in a large town. Buildings in small towns are much cheaper than in cities. Therefore his constant is not correct. A large plant is gen-

erally in a large city. We also have small plants in large cities, and the use of the constant in that case would be inaccurate.

A. P. Criswell.—When I came to figure the interest account, taking into consideration the fact that small plants are built usually where land does not cost much and large plants in large cities where land is a very expensive item, I found that the interest account is not materially different between the 10-ton plant and the 100-ton plant. It amounts to 15 cents a ton all the way through, because of the fact that the site for the small plant cost so much less. Naturally the small plant costs more to build in a given locality in proportion per ton than the large one.

President Block.—That is what Mr. Wolf said.

A. P. Criswell.—But when you come to figure the difference in the interest account, we find that there is no material difference at all. I take it that coal in a well-built plant will be about the same in a small plant as in a large one; the element of water is nearly the same; ammonia and salt are the same; practically, there is no difference between a large and a small plant in these respects. The interest account evens up, too, for the purpose of my table, which was simply to give an approximate table for rough-and-ready reference. I believe I have covered the estimates pretty closely. I do not make any pretensions to exactness; in fact, you will note that I do not take into consideration anything below five cents, because in an approximate estimate of this kind it is useless to try to be exact. There have been a great many tables made and some of them published. I wish to say that these tables, so far as I have been able to observe, are very misleading. I would not say that they misrepresent the cost of making ice. They give what it costs, for labor, ammonia and fuel, and all the other important items are left out. I should have left out the interest account in my table entirely, only for the fact that I desired by that item to bring out the question of better plants. The surprising part of it to me is that the average purchaser is willing to stand for an average plant; but it is a fact that when we are are called upon to figure on a plant, and several of our competitors get on the job with me, we are all trying to see which can put in the lowest bid without any regard to what the cost of ice is going to be; and the point I make is that by adding five cents a ton to the cost in the item of interest account, we can save 25 per cent. on the fuel account. Indeed, we can; there is no question about it. The question is only whether we will do it.

G. A. Robertson.—Take, for instance, a 15-ton plant. You have figured five tons of ice to a ton of coal?

A. P. Criswell.—I figure coal at two dollars and fifty cents a ton, and ordinary coal of that grade will give about five tons of ice to a ton of coal.

G. A. Robertson.—That is in small plants?

A. P. Criswell.—In the average plant. Of course, you know that plants can be shown which give much better fuel results, and where you can show one which will give better I can show a hundred which do not.

Madison Cooper.—I should like to ask, is not the item of depreciation only two and a half per cent.?

A. P. Criswell.—Yes; two and a half to three and a half per cent.

Madison Cooper.—Is not that pretty low?

A. P. Criswell. No; I don't think it is.

President Block.—Is that on the building or the entire plant?

A. P. Criswell.—That is on the entire plant. I intended to go over this table a little more carefully with the insurance men.

F. W. Pilsbry.—If the depreciation covers the entire plant and investment, that would be high enough?

A. P. Criswell.—That depends entirely on the kind of building, and its care. I think on a well-built building, with proper care, that is sufficient to cover it.

Madison Cooper.—I should like to ask what is considered fair depreciation on the mechanical equipment and the building separately?

A. P. Criswell.—I do not think there is very much difference. You put in a first-class ice plant and you will probably not have any repairs which amount to much for four or five years, but if you do not spend a certain amount every year your plant will run down, in a given time, so that you will be called upon to spend very much more. I think 2½ per cent. is enough to cover it ordinarily. I was called last year to look after the repairing of a plant which had been running down for eight or nine years, which cost $50,000 originally; the cost of the necessary repairs was estimated at $26,000. Nothing had been done to that plant for eight or nine years. That sort of management is absolutely inexcusable. In this particular case, however, it was excusable because the property had changed hands and had lain idle for a portion of the time.

H. D. Stratton.—It seems to me that the item of delivery should be added to the cost

A. P. Criswell.—No; I leave that to the selling department of

a business. I am only taking into consideration the manufacture of the ice.

H. D. Stratton.—The man who has to buy it has to pay for all of it, though.

A. P. Criswell.—I did not go into the delivery end at all. It would be impossible in a case of this kind to make out a table. Conditions are so different in different localities.

No. 75.

Discussion of the Topic—

THE INTERNAL COMBUSTION ENGINE AS A PRIME MOVER IN REFRIGERATING AND ICE MAKING PLANTS.

Charles E. Lucke.—That particular characteristic of the internal-combustion engine that has caused people to look toward it as a means of driving a refrigerating plant is its economy. It is today the most economical system of generating power, thermally considered. By means of the internal-combustion engine we are able, without very much difficulty, to transform a larger percentage of the energy of fuel into work than by any other means.

It is also a fact that, under certain cost conditions of fuel and labor and plant, the internal-combustion engine, as a consequence of its high thermal efficiency, will also deliver the cheapest power; but it does not necessarily follow that the cheapest power will always be generated by an internal-combustion engine. As a matter of fact, large plants, especially those of the turbine type, such as we use for our Edison and street-railway systems, are able today to develop power far cheaper, all costs considered, than is possible with any internal-combustion engine system known.

When, however, we decrease the size of the installation from 20,000 to 30,000 or even 100,000 kilowatt capacity to the smaller engines of 1,000 horsepower and under, the situation is entirely changed. The steam consumption of small steam engines is high, and there seems to be no good reason for believing that it will ever be materially improved. The fuel consumption, therefore, of a steam-power station in smaller sizes is ever so much higher than the same powered station in the larger sizes.

On the contrary, the fuel consumption of gas-power stations is about the same, no matter what the size. Now keep this in mind as a fairly correct guide to the relation between the two. The fuel consumption of the largest steam station is about the same as that of the gas station, but the first cost of the gas station is ever so much higher than that of the steam station, and the labor charges and depreciation are correspondingly high. Therefore, in the large sizes

we have about the same thermal efficiency, but a lower generating cost per kilowatt with steam than with gas.

Now consider a decrease in the size. The fuel consumption of a steam station increases; that of the gas station remains about constant. We finally come to a certain size below which the proposition calls for gas power purely and simply, and always will, from present indications, if—and there is the rub—if the power can be generated in suitably available form for the local conditions, or adapted to the service.

What do I mean by that? We are not able today to regulate our gas engines quite as well as our steam engines, especially our turbines; so there is one local condition where the other things are not equal. We cannot claim equal reliability in any size of gas-power stations compared with steam, with possibly one exception, and that is on natural gas. Nor can we find today equally well-trained, universally available operating men. If I should be asked today what is the greatest hindrance to a gas-power station, I would say the operators. A good operator may produce a running condition quite equal to anything which steam can do, and a poor operator who thinks he is better than the other one may take hold of exactly the same station and put it out of business in five minutes. The operating man and the operating and labor conditions are very important factors.

Another factor in which these local conditions that I have mentioned are not equal is the quality of the workmanship. As you know, there are on the market bad steam engines, but the worst steam engine is nowhere near as bad as the worst gas engine. We have not yet reached the point where the average quality in the gas-power field is as high for life and durability as in the steam field.

Given, then, average conditions, I should say that, for twenty-four-hour service, with, perhaps, a great deal of money at stake on stored goods, the gas-power station is a very uncertain proposition today. It can produce power in nearly all sizes used in refrigeration far cheaper than steam can—far cheaper. And when I say far cheaper, I mean sometimes as low as one-fourth of what steam power would cost. But if the operation is not reliable, and there is the possibility of injury to stored goods or disappointing the trade, I cannot see where the advantage comes in. That means that if today anyone is interested in trying to drive a refrigerating equipment with gas power he must, in view of these conditions which I have mentioned, provide himself with spare machinery almost equal in size and efficiency to that already employed. I do

not think it is a very good business proposition to carry one hundred per cent. in spare machinery, especially when the first cost per unit is high.

As the times go on, and the very badly designed and badly built gas engines disappear, and as the producers are made more and more reliable, then the percentage of spares necessary for continuous twenty-four-hour service will be reduced; and when that time comes, unless there is still another objection entering into this problem, I predict something in the way of changed power in refrigerating systems. But the time, in my opinion, has not yet arrived.

The other condition that I had in mind is the possibility of need for producing heat, or availability of condensed steam. It may be that the steam system, with power and heat and use of distilled water combined, produces a better combination than the gas-power station, even though the latter can produce cheaper power.

As to the difference in the reliability of the different systems, we may have a gas engine deriving its fuel from gas manufactured in the city or from the natural-gas supply. Engines using such gas can be made, if the manufacturers will only get to work on them and the purchasers pay the price, just as reliable as the steam engine, every bit.

Next, we have the gas-engine-producer combination, using, let us say, anthracite coal, and the same combination using bituminous coal. There is not today a satisfactory bituminous producer available, in spite of what producers of equipment will say—and I am one of them. I have a pet scheme of my own, but I am not yet offering it for sale. As there is not a satisfactory bituminous producer today, we can eliminate that from the field.

There are fairly satisfactory anthracite producers, but they will not give twenty-four hours' service 365 days in the year. They will not, because of clinkers and ash-removal difficulties requiring that they be shut down occasionally. That means spares—not necessarily one hundred per cent. of spares; but if you have only a small equipment in a coal producer, you cannot have any spare producer without having one hundred per cent. Now what is left? The oil engine. The oil engine may be using gasoline, kerosene, or some equivalent distillate, or a crude oil, or what is equivalent to a residue oil. No residue-oil nor crude-oil engines that I know of can be relied upon for twenty-four hours' service 365 days in the year, because I know of none that will operate without some carbonization, which means cleaning in time, the time varying, perhaps, from two or three days to several months, and varying in the number of

hours it must be shut down in order to do the cleaning. The distillate engine, using kerosene or dense distillate, is a good possibility for an engine, but is practically non-existent. The gasoline engine is, and can be made, if well built, just as reliable as an engine running on natural gas or city gas, and can be relied upon for twenty-four-hour service; but the best we have today is none too good.

However, my figures of the cost of power do not apply so well to the gasoline-driven machines, or to machines supplied from a city gas main, because gasoline and city gas are the most expensive forms of fuel that we have today.

I would say, then, in conclusion, that, as a general proposition, the internal-combustion engine as power equipment for driving refrigerating machinery is a thing which must be approached with great caution, for the reasons I have given, and for some others, which I have not mentioned. There are conditions under which it can be relied upon; there are far more cases where it cannot be relied upon; but you may expect improvements; and when reliability, labor conditions, machine work and good business principles have prevailed long enough we will be able to drive all our equipment by this system of power at much less cost than now.

I think it is, therefore, a subject for us to continue to study.

President Block.—Is it not possible to run an oil engine for thirty days, twenty-four hours a day, without shutting down?

Charles E. Lucke.—It has been done under favorable conditions, and it can be done under such conditions; but with an operator who is not properly skillful, or with a change in oil supply, even though it be delivered by the oil company under the same name as the previous lot, conditions may be so changed as to cause unexpected difficulty. All things being favorable, yes; and longer.

President Block.—I mentioned it because I know of such a case.

Charles E. Lucke.—Yes; and longer than that, too.

President Block.—Thirty days' operation at a time, then a shutdown for a few hours, and then going on again.

Charles E. Lucke.—Yes. But change operators and it may not happen; or order a new supply of oil, which may not be the same as you had the last time, you may not do it.

V. R. H. Greene.—If producer gas proves to be a less expensive power, suppose you install a duplicate producer; will it then be possible to operate the engine with freedom from tar troubles if you use hard coal?

Charles E. Lucke.—I think so. I think with a spare producer twenty-four-hour service may be had; provided the engine is a good,

husky, well-built machine and properly operated, it is pretty nearly a possibility; but the mere delivery of gas to the engine does not keep it going. The gas must be a uniform gas. It does not make so much difference whether it is a rich gas or a poor gas; so long as it is constant, the engine can be built to use it, and will run so long as the constancy exists. Should the gas vary through the carelessness of the operator or the clinkered condition of the producer, the engine may fail to carry its load. So the chances of not maintaining twenty-four hours' service make me tell you to be very cautious. It may be all right, and again it may not be.

In regard to the tar, there are tar extractors, but I know of no tar extractor that will take out all the tar; and unless we get out all the tar, the extraction of barrels of it, which, with pride, can be shown standing around the plant, does not mean anything. A very thin film of tar, infinitesimal in thickness and almost invisible, so far as color is concerned, just a brownish color, on a well-fitting inlet-valve stem or governing valve, will bind it so that it cannot be moved without taking it apart. I know of a case in which a sliding sleeve—let us say 10 inches in diameter and a couple of feet long—driven with a rocker-arm twice as thick as my own arm, became clogged by an almost invisible film of tar, and after the engine had been shut down over night and started up in the morning the sleeve stuck so tightly that it broke the cast-iron rocker lever. That is an example of tar consequences, and there is not today any tar extractor which will take out all the tar.

Conrad H. Young.—I believe Doctor Lucke is familiar with conditions in Great Britain. Is it not true that they are operating gas-producer systems with gas engines, operating some cold storage plants there in this way exclusively?

Charles E. Lucke.—Yes. Conditions in Great Britain are somewhat different than they are here—chiefly in two respects, or possibly three.

First, the quality of engines is higher than ours—not because their best is any better than ours so much as that their worst is not so bad as our worst. It is also the same with the producers.

Second, their labor conditions are better. The English operating man is a far more reliable man than the American operating man, especially the one in charge of a small plant. Any old "scrub machinist" today is put to work operating a 25 horsepower engine, and they think he ought to get results, but he cannot do it. In England that is not the case. Those men regard themselves as persons of importance. They study at night schools. I know graduates

of technical universities in England who do not consider it a condescension to run such a plant. All labor conditions there are different and better.

Then the coal. They do not have such a variety of coal; and, just as an engine is sensitive to a change of gas more than to the requirements of high or low quality, so is a producer sensitive to a change of coal. I have doubts about there ever being produced a universal producer. So far, producers have been designed and adapted to special coals. In England they have less variety of coal than here, and the chances of running the producers are far better. Here we can order coal by mine name, by the name of the dealer, or by some trade name, and the conditions of the coal market are such that you can be no more sure of getting the same coal in each succeeding lot than you can with your oil supply. The fact that England is doing this makes me feel confident that we are going to do it. I am also willing to repeat what I have already said, that there are conditions today which might be studied out as favorable to the proposition; but as a general proposition I would say: Be careful.

Fred W. Wolf.—I should like to know what the speaker has to say about the Diesel engine.

Charles E. Lucke.—The Diesel engine has long been a subject of controversy, so that anything I may say will not be decisive. It is a German engine that has a record for high thermal efficiency; but it is an expensive engine, and it is a highly sensitive engine, and I would not depend upon it for any continuous service in this country at this time.

President Block.—I referred to a Diesel engine when I said I had known one to run for thirty days at a time and then, with a six hours' shutdown, it ran thirty days more. It was very satisfactory when using crude oil.

Charles E. Lucke.—And I think, to offset that, a number of cases can be found where the plant could not be kept running without excessive care and repairs.

President Block.—I saw a published statement the other day of where a plant had over two hundred thousand dollars' worth of Diesel engines, and the repair bill for the first eighteen months was only seventeen hundred dollars. That seemed to me to be very satisfactory, and a very small repair bill.

Charles E. Lucke.—Yes, it is; that is why they published it.

H. Rassbach.—I do not think that the Diesel engine should be condemned in the way it seems to me it has been. I have seen Diesel

engines which were built and operated in this country. I have seen many of them here, and many of them have been removed from the places where they were originally installed. Two years ago I saw an installation of twelve hundred horsepower in units of four hundred horsepower each, and I dare say that, after seeing this plant day by day and visiting it in order to find out if there was any defect in it, I would not wish to have a better power plant than the one I mention. Those three machines were simply perfect, and they ran continuously—that is, two at a time for at least four weeks—without ever being cleaned. They used oil, and the operators were very careful, of course. It is a very sensitive engine, and it requires an A1 operating engineer to keep it in order.

Charles E. Lucke.—I am very glad to have this contribution, because that is my position exactly. Mr. Wolf and I are not opposed to each other at all. When I said I would not put in a Diesel engine I meant here in America, under our present conditions. I predict a change of affairs here, and that change is in existence in Europe today—more in Germany, perhaps, than in England; yet in the German power stations they are at a great advantage in the matter of labor, much greater than would ever be possible here. They pay their men so little in proportion to the cost of fuel as to change their economic condition. Conditions are not the same here. Here labor is high, of poor quality, and our fuel is comparatively cheap; so that your contribution really bears out what I said exactly.

President Block.—I have been informed that the Diesel engine is very successful in Germany and Switzerland, and has been so for a good many years, and that the best builders are engaged in the manufacture of this engine.

Charles E. Lucke.—I might add in that connection that the Diesel patents either have expired or are about to expire, and that many manufacturers of other types of engine are considering the building of this engine, which they would not do after seventeen years of observation of operation if it had not been a reasonably successful engine.

No. 76.

Discussion of the Topic—

WHAT CAN BE DONE TO PREVENT ELECTROLYTIC ACTION UPON STEAM CONDENSER TUBES WHEN SEA WATER IS USED FOR CONDENSING PURPOSES.

President Block.—As you all know, when sea water is used for the purpose of condensing steam in an ordinary surface condenser, in which muntz metal tubes are used, there is, sooner or later, corrosion taking place. The tubes finally become perforated. They have the appearance of pitting on the outside; but, upon closer investigation, it is found that the corrosion takes place on the inside; from a hole as large as the head of a pin it increases until finally there is a hole, or a series of holes, in the tube.

I met with such a condition once and consulted an electrical engineer about it. As a street car ran near our place, he said it was a simple matter—we could lay a wire around the house and get rid of the trouble in that way. He ascertained the degree of the electric current, and it was quite considerable; and we did lay a wire around the house, but at the same time we changed from salt water to fresh water and a cooling tower; and I don't know whether his wire did it or not, but at any rate we have had no more trouble with electrolysis since then.

Another case came under my notice. In Porto Rico there was a 25-ton ice plant; they were using water out of the bay; they had a condenser which lasted for seven years. They found evidences of pitting, as they called it, and they thought it might be well to have a spare condenser. So they purchased another condenser, and inside of four months the tubes in that condenser were gone. They then purchased another set of tubes from the same manufacturer, and in about five weeks those tubes were pitted. They then refused to pay for the tubes, and were sued for the cost of the tubes of the condenser furnished, and they lost the suit, because it was held that particles of carbon floating in the bay, deposited there from the smokestack of the plant, were drawn into the tubes, and wherever the particles of carbon located the electrolytic action was

produced and the tubes eventually became perforated. An expert was called, and he examined these tubes. It was clearly demonstrated that the eating away of the tubes started on the inside, although the outside of the tubes appeared also to be pitted—that is, there were slight depressions in the surface. This expert said that in the Waterside station of the Edison Company, in New York, which is of enormous size, developing seventy-odd thousand horsepower, some of their condenser tubes lasted five or six weeks and some of them more than two years; that in order to ascertain whether it was electrolysis produced by the generators in the station they had taken a bundle of these tubes and put them into a wooden box, through which the water from the condenser would flow before it returned to the river, and they had taken pains to prevent any electrolysis anywhere in the neighborhood of these tubes; and these tubes were affected in exactly the same way as the tubes in the condenser. I contended that the tubes which had a larger proportion of copper—so-called Admiralty mixture—would be better than what is called muntz metal or muntz mixture. A very large representation of the tube manufacturers of this country were in the court room, and every one of them swore that muntz metal was the proper metal for condenser tubes, because, if they had not sworn so and had fixed that point so that the court rendered a decision based upon this expert testimony, most likely every one of those condenser tube manufacturers would have had a suit on his hands for furnishing tubes for the Waterside station of the Edison Company, which were not of proper material or quality. Men who have sold condenser tubes since 1850 were in court, and swore that muntz metal was the only and proper material and mixture for condenser tubes. If corrosion is brought about by the tubes being in contact with particles of carbon floating in a river, then I should say the water should be filtered by a sand filter before it is used in the condenser, and the deposit ought to be prevented; and that would bring about an enormous saving in stations such as the Edison Waterside station.

Otto Luhr.—I had an experience in a brewery in Rochester. This was not on a condenser, but on a square hot-water tank, with iron coils in it. This tank was equipped with galvanized iron coils, and after three years' time all the coils were pitted through, the tank was pitted on the inside, and all the braces were practically pitted. The water of Rochester is a very harmless water. I had the water analyzed in different places, with the same results, but they could discover nothing in the water which could possibly cause this corrosion or this pitting. So after I had that knowledge I searched for

causes, and found that in the small electrical plant there were a number of bad ground circuits, and that some of the wires were in contact with the water pipes, which led me to believe that that was the cause of it. So I said: "We will remove the grounding from these wires," which we did; and then we put new coils in the tank and left the tank as it was. The tank was quite thick, and the pitting on the inside did not do very much harm; but we had to put in new braces. This was about six years ago. I go to Rochester every year, sometimes twice a year, and each time have this tank emptied, but have found no pitting since. So the cause must have been from the grounded current that we discovered.

President Block.—I am informed that electrolysis only takes place where the water leaves the surface, as, for instance, on an atmospheric condenser. Where you have a submerged coil, I do not see how it could take place at all.

Otto Luhr.—It did, and we stopped it.

Charles E. Lucke.—I know a few facts. Thinking the cause of the corrosion was electric, the Westinghouse-Church-Kerr Company, when they erected the Long Island power station across the river from Thirty-fourth street, in New York, installed a little generator, which was suitably attached to the condenser, to generate a counter current to neutralize the other current, and it went so far that one of the members of the firm announced, in a lecture, that he had solved the problem; but I believe they are still replacing the tubes.

I had occasion to investigate, for another large New York City power station, some tubes in a condenser that exhibited different characteristics than are ordinarily observed. These tubes, instead of being in any way pitted, looked to be perfectly good; but if you would drop one of them on the floor it would break like a piece of glass. We had those tubes examined microscopically, and micro-photographs were taken. The micro-photographs showed that the brittle tube had practically lost all of its zinc, and the copper that was left was there as a copper sponge, the particles being hardly in contact, much the same as rock-candy. But we were unable to find out why the zinc left, whether it was electrolytic or some solution action. That, however, gives a pretty clear idea of what is happening in these tubes. They are losing their zinc. The cause of the loss, I believe, after studying it somewhat, may be either simple solution action or electrolytic; in some cases possibly both together.

President Block.—How would you explain the solution action?

Charles E. Lucke.—That is rather a long story.

President Block.—If you have the tubes tinned, that does not seem to help it in the slightest degree?

Charles E. Lucke.—No.

President Block.—A tinned tube will be affected in exactly the same manner as an ordinary brass tube?

Charles E. Lucke.—It is more strange when you consider that the metallic tube is not a mere mixture of copper and zinc, but a real alloy, having a different molecular structure entirely than either copper or zinc, and yet the zinc leaves it. It is a most extraordinary thing.

President Block.—Then there does not seem to be any solution of the question as yet. I know they are still experimenting at the Edison Waterside station, and Mr. Lentz, I think it was, made the statement that it was brought about by the particles of carbon. If that is the case, then a filtration of the water would prevent it.

PROCEEDINGS

OF THE

FIFTH ANNUAL MEETING

OF

THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS

NEW YORK, N. Y., December 6, 1909.

The American Society of Refrigerating Engineers held its fifth annual meeting in the Engineering Societies' building, 29 West Thirty-ninth street, New York, N. Y., on Monday, December 6, 1909. Two sessions were held, Monday morning and afternoon, both being called to order and presided over by President Louis Block.

First Session, Monday Morning, December 6, 1909

The first session of the meeting was called to order at about 10:30 o'clock A. M., and as more than a quorum were present the roll-call was dispensed with.

The first order of business was the reading of the minutes of the special meeting held in Chicago, Ill., on Oct. 18 and 19, 1909, which were approved. They were as follows:

MINUTES OF THE SPECIAL MEETING OF THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS, HELD IN CHICAGO, ILL., ON OCTOBER 18 AND 19, 1909.

The American Society of Refrigerating Engineers held a special—the first Western—meeting of the Society in the Stratford Hotel, Chicago, Ill., on Monday and Tuesday, October 18 and 19, 1909. About one hundred and twenty-five members and guests were in attendance. Four sessions were held, Monday morning, afternoon and evening, and Tuesday morning, all being called to order and presided over by President Louis Block.

FIRST SESSION, MONDAY MORNING, OCTOBER 18, 1909

The first session of the meeting was called to order at about 10:45 o'clock A. M., and as more than a quorum were present the calling of the roll of members was dispensed with, and the meeting was declared open for business.

The minutes of the fourth annual meeting were then read and approved.

The report of the Tellers of Election of Membership was next in order, and they reported that the following applicants had been elected to membership since the fourth annual meeting in the grades indicated:

MEMBERS

Gustav R. Bostrom.....York, Pa.
William M. Chatard..Baltimore, Md.
Heywood Cochran.....Chicago, Ill.
George H. H. A. Geisler, Oakland, Cal.
George H. Fisher.Leavenworth, Kan.
Albert T. Marshall..Hartford, Conn.
Louis S. Morse.....York, Pa.
Adelbert W. Sterrett.Tacoma, Wash.

ASSOCIATE MEMBERS

Robert J. Berryman...Annapolis, Md.
Carl Hausmann, Wellington, New Zealand
James J. Hinde.....Sandusky, Ohio
Charles A. Hovey..Washington, D. C.
Alexander M. McDougall, Duluth, Minn.
Louis A. Phillips...New York, N. Y.
George H. Sethman.....Denver, Col.

JUNIOR MEMBERS

Gustave H. Delareuelle.Oakland, Cal.
Walter W. Sandholt...Oakland, Cal.

They also reported that Alvin H. Baer, Waynesboro, Pa., had been advanced in membership from Junior Member to Member.

The President then declared the successful applicants duly elected to their respective grades and entitled to the rights and privileges of membership, if they had complied with the provisions of the Constitution and By-Laws covering new members.

An informal report was now made by the Joint Committee of The American Society of Refrigerating Engineers and The American Society of Mechanical Engineers, appointed to suggest a standard tonnage basis for refrigeration and methods of testing refrigerating apparatus, by John E. Starr of the committee. Mr. Starr stated that the committee begged to report more than mere progress, in that the committee had made a definite step forward by drafting a letter and sending it to the refrigerating engineers, refrigerating machine manufacturers and prominent users of refrigerating machinery, to draw from them an expression of their opinion on one or two points which should really be the starting point of the work of the committee. He then read the letter that the committee had sent out. It is as follows:

JOINT COMMITTEE ON REFRIGERATION

To Refrigerating Engineers, Refrigerating Machine Manufacturers and Users of Refrigerating Machinery:

DEAR SIRS:—A joint committee has been appointed by The American Society of Refrigerating Engineers and The American Society of Mechanical Engineers to suggest a standard tonnage basis for refrigeration. In this connection the committee would like to obtain the co-operation of refrigerating machine builders and all others interested in the art, and therefore submits the following tentative report for your consideration, and invites your comment as to the condenser and refrigeration temperatures and pressures proposed as a standard set of conditions:

The subject will be considered under two heads—

A. The selection of units to measure the cooling effect or the refrigeration produced.

B. The selection of a standard set of conditions under which a refrigerating machine, no matter what its type, shall be run in determining what is herein designated as its commercial tonnage capacity.

The unit adopted to measure the cooling effect, or the refrigeration, is the heat required to melt one pound of ice, which is ordinarily taken at 142 British thermal units. By dividing the refrigeration, measured in British thermal units, by 142, the ice-melting capacity in pounds is obtained. The very latest determinations of the latent heat of fusion of ice will be looked up, and if it appears that a more reliable value than 142 British thermal units has been established the more exact value will be used. The unit for a ton of 2,000 pounds of ice-melting capacity is therefore 284,000 British thermal units. This committee feels that this tonnage unit cannot be improved upon, and herewith recommends its adoption.

The commercial tonnage capacity is the refrigerating effect, expressed in tons of ice-melting capacity, produced by a machine in 24 hours when running continuously under the standard set of conditions.

Considering the matter from the standpoint of cost of plant and of steam and water economy, the best set of conditions to adopt seems to be those which often exist in ice making, namely, that the temperature of the saturated vapor at the point of liquefaction in the condenser be 90 degrees Fahr. and the temperature of evaporation of the liquid in the refrigerator be 0 degree Fahr. This corresponds for ammonia to a condenser pressure of about 168 pounds per square inch above the atmosphere, commonly called gauge condenser pressure, and to a pressure of about 15 pounds per square inch in the refrigerator, commonly called gauge back pressure.

The committee will devise a set of conditions or factors for the purpose of calculating the actual refrigerating capacity under various sets of conditions as to condenser and suction pressures, so that when other temperatures and pressures are used a proper correction may be made.

F. E. MATTHEWS, *Secretary.*

Mr. Starr further stated that over 50 replies had been received to the letter, and that the replies would be of great assistance to the committee. In concluding his remarks he stated that the committee was simply trying to get at the nearest standard of refrigeration and the nearest method of testing refrigerating apparatus that it could, to report them to the two Societies. The committee's report will give the consensus of opinion of the refrigerating engineers and builders of refrigerating machinery, and he hoped that the work of the committee would bring the manufacturer and buyer of refrigerating machinery and the refrigerating engineer a little closer together.

The committee's report was accepted.

The Nominating Committee then announced its nominations for the offices falling vacant at the next annual meeting. They were as follows:

President—Roderick H. Tait, St. Louis, Mo.
Vice-President—Charles E. Lucke, New York, N. Y.
Directors—Edward N. Friedmann, New York, N. Y.; Gardner T. Voorhees, New York, N. Y.; Charles Dickerman, Philadelphia, Pa.
Treasurer—Walter C. Reid, New York, N. Y.

President Block now appointed the following Resolutions Committee to draft resolutions on the deaths of Francis H. Boyer, Henry Blethen and Alfred Siebert, and to report at the annual meeting in New York on December 6, 1909; Theodore O. Vilter, Milwaukee, Wis.; John E. Starr, New York, N. Y., and F. W. Pilsbry, Chicago, Ill.

The address of President Block was now received with marked attention and applause.

The following two papers were presented at this session: "The Cold Storage Warehouse as a Fire Hazard," by Joseph B. Finnegan, Chicago, Ill., and "Water Purification for Ice and Refrigerating Plants," by J. C. William Greth, Pittsburgh, Pa.

A vote of thanks was extended both Mr. Finnegan and Mr. Greth for their interesting papers.

The session adjourned at this point for luncheon, as the guests of the Chicago members of the Society.

SECOND SESSION, MONDAY AFTERNOON, OCTOBER 18, 1909

The second session of the meeting was called to order shortly after 2 o'clock P. M.

The first business to come before this session was the appointing of a Special Resolutions Committee to draft a letter of greeting to the American Meat Packers' Association, in convention at the Hotel La Salle. The President appointed John C. Atwood, St. Louis, Mo.; Walter L. Hill, Boston, Mass., and R. H. Tait, St. Louis, Mo., on this committee.

The following three papers were presented at this session:

"What is the Meaning of the Term Efficiency?" by Peter Neff, Canton, Ohio; "The Ice Factory of the Future," by Victor H. Becker, Chicago, Ill., and "The Refrigeration of Dairy Products," by John A. Ruddick, Dairy and Cold Storage Commissioner of Canada.

The Special Resolutions Committee appointed to draft a letter of greeting to the American Meat Packers' Association now made its report by offering the following letter, which was accepted and ordered sent by the meeting:

CHICAGO, ILL., October 18, 1909.

The American Meat Packers' Association, in Convention Assembled in the Hotel La Salle, Chicago, Ill.:

GENTLEMEN:—The American Society of Refrigerating Engineers, in convention assembled in the Stratford Hotel, Chicago, Ill., extends you its greetings and best wishes for the success of your deliberations, and, remarking the mutuality of our interests, cordially invites such of your members as feel they can spare the time from your own important discussions to all of the courtesies of our meeting.

Respectfully,

(Signed) LOUIS BLOCK, *President.*

(Signed) W. H. Ross, *Secretary.*

The following topics were also discussed at this session:

"The Internal-Combustion Engine as a Prime Mover in Refrigerating and Ice-Making Plants," and "What Can be Done to Prevent Electrolytic Action Upon Steam Condenser Tubes When Sea Water is Used for Condensing Purposes?"

The session then adjourned.

THIRD SESSION, MONDAY EVENING, OCTOBER 18, 1909

The third session was called to order shortly after 8 o'clock P. M.

The following two papers were read at this session:

"The Flooded System and Its Application to Ice Making and Refrigerating Plants," by H. Rassbach, Milwaukee, Wis., and "Autogenous Welding," by Fred. W. Wolf, Jr., Chicago, Ill.

A motion prevailed thanking Mr. Rassbach for his splendid paper.

Dr. Charles E. Lucke also made a few remarks on "The Economy of Wet vs. Dry Compression and Its Dependence on the Properties of Saturated Ammonia Vapors" that was highly interesting.

The session then adjourned.

FOURTH SESSION, TUESDAY MORNING, OCTOBER 19, 1909

The last session of the meeting was called to order at about 10 o'clock A. M.

The following four papers were presented at this session:

"Cold Storage Temperatures and Arrangement of Cold Storage Warehouses for Handling All Classes of Merchandise," by Walter L. Hill, Boston, Mass.; "The Thermodynamics of Saturated Vapors and Related Energy Problems," by Dr. J. E. Siebel, Chicago, Ill.; "The Comparative Value of Direct and Indirect Refrigeration for Cold Storage Plants," by Nelson J. Waite, Cleveland, Ohio, and "Approximate Cost of Making Ice in Plants of Different Sizes, Each Operating Under Similar Conditions," by A. P. Criswell, Chicago, Ill.

J. C. Goosmann, Chicago, Ill., also gave an extremely interesting illustrated lecture on "Low Temperatures in Surgery and Microscopy."

A hearty vote of thanks was extended Dr. J. E. Siebel for his very valuable paper.

Dr. Charles E. Lucke, New York, N. Y., presented the following resolution, which was unanimously accepted:

RESOLUTION ON PHYSICAL CONSTANTS

WHEREAS, The members of The American Society of Refrigerating Engineers have come to a realization of the inaccuracy of the physical constants used in calculating the dimensions and performance of refrigerating and ice-making apparatus; and

WHEREAS, It is of great importance not only to the members of The American Society of Refrigerating Engineers, but also to all industries depending upon mechanical refrigeration, that these constants be carefully determined; and

WHEREAS, The determination of the values of these constants is a difficult and expensive undertaking, beyond the scope of any individual and beyond the scope of the usual university equipment; and

WHEREAS, The United States Government maintains physical laboratories with men and equipment suitable for these determinations; and

WHEREAS, The United States Government has contributed to the advancement of agricultural and other industries to the extent of millions of dollars yearly,

Be it Resolved, That the President of The American Society of Refrigerating Engineers appoint a committee to secure the co-operation of all the industries dependent upon refrigeration, and proceed together with their representing committees to confer or communicate with the Secretary of Commerce and Labor, with a view to securing an order on the directors of the laboratories under the charge of the Department of Commerce and Labor to make correct and accurate determinations of the physical constants necessary in calculating the dimensions and performance of refrigerating machinery.

In accordance with the resolution of Dr. Lucke, the President appointed Dr. Charles E. Lucke, Chairman; Dr. D. S. Jacobus, New York, N. Y.; John E. Starr, New York, N. Y.; F. E. Matthews, New York, N. Y., and Gardner T. Voorhees, New York, N. Y., on this committee.

Professor K. G. Smith, of the University of Illinois, who was a guest of the Society, suggested that his institution be included in the resolution of Dr. Lucke, and Victor H. Becker, Chicago, Ill., moved that the President appoint a committee from the Illinois members of the Society to request the University of Illinois to undertake experiments along the line suggested by Dr. Lucke in its engineering experiment station. The motion carried.

The President appointed the following Illinois members on this committee: Victor H. Becker, Chicago, Ill.; A. P. Criswell, Chicago, Ill., and Otto Luhr, Chicago, Ill.

The Illinois Steel Company, through General Superintendent William A. Field, extended an invitation to the members of the Society to visit its plant in South Chicago on the afternoon of Tuesday, October 19. A large number of the members availed themselves of this invitation.

G. J. Patitz extended a cordial invitation on behalf of the Peter Schoenhofen Brewing Company, Chicago, Ill., to the members of the Society to visit its brewery while in Chicago, and a number enjoyed a trip to the brewery.

There being no further business before the meeting, President Block closed the meeting with the following remarks:

"Now, gentlemen, I thank you for your attention, and I want to assure you that it has been a pleasure to preside over the deliberations of such genial spirits as I have found in you. I thank you."

(Signed) W. H. Ross, *Secretary.*

The next order of business was the reading of the minutes of the fourth annual meeting. They were approved as read and will be found in the Proceedings of the Chicago Meeting elsewhere in this volume.

The report of the Tellers of Election of Membership was now received. It follows:

REPORT OF TELLERS OF ELECTION OF MEMBERSHIP

NEW YORK, N. Y., November 23, 1909.

Mr. Louis Block, President, The American Society of Refrigerating Engineers, 154 Nassau Street, New York, N. Y.:

DEAR SIR:—Your Tellers of Election of Membership have canvassed the ballots of November 22, and find that 109 votes were cast, 3 of which were void, and beg to report that the following applicants have been elected to membership in the Society in the grades indicated:

MEMBERS

Guy Bates, New York, N. Y.
Victor H. Becker, Jr., St. Louis, Mo.
Gustave F. Bein, Kansas City, Mo.
John Lathrop Gray, Bayonne, N. J.
Herbert S. Nulsen, New York, N. Y.
Gerhardt J. Patitz, Chicago, Ill.
Albert Ruemmeli, St. Louis, Mo.

ASSOCIATE MEMBERS

William N. Bavier, New York, N. Y.
Peter Binzel, Jr., Hoboken, N. J.
John L. Hughes, No. Yakima, Wash.
Eugene F. McPike, Chicago, Ill.
O. S. Stockman, Pittsburgh, Pa.

JUNIOR MEMBERS

Robert N. Bavier, New York, N. Y.

Respectfully submitted,
(Signed) H. BORGSTEDT, *Chairman.*
L. HOWARD JENKS.
FRANKLIN H. HERST.
} *Tellers of Election of Membership.*

President Block then declared the successful applicants duly elected to their respective grades and entitled to the rights and privileges of membership if they had complied with the provisions of the Constitution and By-Laws covering new members.

The report of the Council was now heard and accepted.

REPORT OF THE COUNCIL OF THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS FOR THE YEAR ENDING DECEMBER 4, 1909

The amount of real and personal property owned by the Society, the property acquired during the year, the amount applied, appropriated or expended, and the purposes and objects for which such expenditures have been made are contained in the report of the Finance Committee, which follows:

REPORT OF THE FINANCE COMMITTEE

NEW YORK, N. Y., December 4, 1909.

Mr. Louis Block, President, The American Society of Refrigerating Engineers, 154 Nassau Street, City:

DEAR SIR:—Your Finance Committee has to report as follows for the fiscal year ending December 4, 1909:

Balance on hand November 28, 1908		$297.13
RECEIPTS		
Initiation fees	$155.00	
Dues	1,820.23	
Emblems	49.50	
Transactions	93.51	
Banquet	469.00	
Total		2,587.24
Grand total		$2,884.37
DISBURSEMENTS		
Printing	$722.18	
Emblems	36.00	
Rents	325.52	
Caterers	530.00	
Membership certificates	9.75	
Furniture	64.50	
Premium on Treasurer's bond	5.00	
Salaries	500.00	
Telephone	3.00	
Stenographic reports of meetings	281.25	
Petty cash	263.10	
Total		2,740.30
Balance on hand		$144.07

Respectfully submitted,
(Signed) F. W. PILSBRY, *Chairman.*

The Council held three executive sessions—February 17, June 22 and November 3—during the past year, your President presiding at each meeting, and it respectfully presents herewith a report of the business transacted, along with other matters that should be of interest to the membership.

At the first meeting, on February 17, W. H. Ross was reappointed Secretary of the Society, and an appropriation of $600 was made to cover his salary and the services of an office stenographer for the year.

President Block made the following committee appointments on February 8:

MEMBERSHIP COMMITTEE

Thomas Shipley, *Chairman*, York, Pa. W. H. Manns, Waynesboro, Pa.
N. H. Hiller, Carbondale, Pa.

FINANCE COMMITTEE

F. W. Pilsbry, *Chairman*, Chicago, Ill. J. J. De Kinder, Philadelphia, Pa.
Karl Wegemann, New York, N. Y.

PUBLICATION COMMITTEE

John C. Wait, *Chairman*, New York, N. Y. Madison Cooper, Watertown, N. Y.
Llwellyn Williams, Boston, Mass.

PROGRAMME COMMITTEE

Karl Vesterdahl, *Chairman*, New York, N. Y. Walter C. Reid, New York, N. Y.
N. H. Hiller, Carbondale, Pa.

TELLERS OF ELECTION OF MEMBERSHIP

H. N. Borgstedt, *Chairman*, New York, N. Y. L. Howard Jenks, New York, N. Y.
Franklin H. Herst, Philadelphia, Pa.

NOMINATING COMMITTEE

Edgar Penney, *Chairman*, Newburgh, N. Y. W. Everett Parsons, New York, N. Y.
John E. Starr, New York, N. Y.
D. S. Jacobus, New York, N. Y. Peter Neff, Canton, Ohio.

At the first meeting of the Council a motion prevailed that the Secretary send a letter to each member of the Society advising them that the discussion on the paper read at the fourth annual meeting by Charles E. Lucke on "Performance of Ammonia Compression Machines" be made in writing, and forwarded to the office of the Society by April 1, 1909, in accordance with a resolution passed at the fourth annual meeting.

The Publication Committee has had the transcript of the discussions on the papers read at the fourth annual meeting corrected and it is now in the hands of the Secretary, but he has not had time to have it put in type, and the fourth edition of the Transactions printed and issued to the membership, on account of the large amount of time and work required to arrange for the Chicago meeting of the Society, and on account of personal matters requiring his attention. The fourth edition of the Transactions should be issued early in the new year.

The following have been elected to the membership in the Society during the year in the grades indicated:

MEMBERS

Guy Bates, New York, N. Y. Gustav Ralf Brostrom, York, Pa.
Victor H. Becker, Jr., St. Louis, Mo. William M. Chatard, Baltimore, Md.
Gustave F. Bein, Kansas City, Mo. Heywood Cochran, Chicago, Ill.

George H. Fisher, Leavenworth, Kan.
George H. H. A. Geisler, Oakland, Cal.
John Lathrop Gray, Bayonne, N. J.
Albert Tisdale Marshall, Hartford, Conn.
Louis Shepard Morse, York, Pa.
Herbert S. Nulsen, New York, N. Y.
Gerhardt J. Patitz, Chicago, Ill.
Albert Ruemmeli, St. Louis, Mo.
Adelbert W. Sterrett, Tacoma, Wash.

ASSOCIATE MEMBERS

William N. Bavier, New York, N. Y.
Robert James Berryman, Annapolis, Md.
Peter Binzel, Jr., Hoboken, N. J.
Carl Hausmann, Wellington, New Zealand.
James J. Hinde, Sandusky, Ohio.
John L. Hughes, No. Yakima, Wash.
Charles Albert Hovey, Washington, D. C.
Alexander M. McDougall, Duluth, Minn.
Eugene F. McPike, Chicago, Ill.
Louis A. Phillips, New York, N. Y.
George Henry Sethman, Denver, Col.
O. S. Stockman, Pittsburg, Pa.

JUNIOR MEMBERS

Robert N. Bavier, New York, N. Y.
Gustave Henry Delareuelle, Oakland, Cal.
Walter Wesley Sandholt, Oakland, Cal.

Alvin H. Baer, Waynesboro, Pa., has been advanced in membership from Junior Member to Member.

Five applications for membership have been received since the last ballots for new members issued.

The resignations from membership of Charles E. B. McReddie, Buenos Aires, Argentine Republic, and Robert J. Graham, Belleville, Ontario, Can., have been accepted by the Council with regret.

Your Treasurer was authorized to purchase a safe for the office of the Society and it is now in use. The purchase of additional filing cabinets was also authorized and they are in use.

At the meeting of the Council on June 22, it was decided to hold a special meeting of the Society in Chicago, Ill., on October 18 and 19 and the Programme Committee was instructed to prepare an interesting programme and arrange for this meeting. The splendid results of their efforts should be known to all of you. The Council hopes that other meetings may be held in the West at least every other year, which should result in adding to the membership of the Society from the West and enhance the importance of the Society in the field of engineering and its value to the membership.

A motion prevailed at the meeting on June 22, instructing the Membership Committee to communicate with the references of an applicant when it finds it cannot approve the applicant's application for membership in the grade of membership sought, that the references may have an opportunity to submit additional information looking toward the committee approving the application in the grade of membership desired.

Another motion to receive favorable action at the meeting on June 22 instructed the Membership Committee to advise the references of an applicant for membership, whose application has been rejected by the Committee, of such action, that the references may submit additional information or that the applicant may have occasion to withdraw his application.

Twelve members have been dropped from the roll of members during the year for non-payment of dues.

The exchange of the Society's Transactions for the Transactions of the American Society of Mechanical Engineers has been authorized.

The Council regrets to report the death of three members of the Society during the past year. Francis H. Boyer died at Somerville, Mass., on February 21; Henry Blethen died at Seattle, Wash., on April 24, and Alfred Siebert died at St. Louis, Mo., on July 20. It hopes suitable resolutions on their lives and work may be offered at this meeting.

A member has suggested the addition to the grades of membership of Honorary Member and the Council thinks this suggestion should be discussed at this meeting.

Your President has appointed the following members as Tellers of Election of Officers: Fred W. Wolf, Jr., *Chairman,* Chicago, Ill.; James Ely, New York, and Frank H. Abbey, Boston, Mass.

The Governor of the State of Missouri, the Mayor of the City of St. Louis, the Business Men's League of the City of St. Louis, the Merchants Exchange of the City of St. Louis, the Missouri Manufacturers' Association, the Million Population Club of the City of St. Louis and several of our Western members invite the Society to hold its next Western meeting in the city of St. Louis. While this is a matter for the Council to finally decide, it asks the members for an expression of opinion.

Respectfully submitted,

(Signed) LOUIS BLOCK, *President.*

John E. Starr, for the Joint Committee of The American Society of Refrigerating Engineers and The American Society of Mechanical Engineers, reported that the committee had not accomplished anything further since the Chicago meeting, except to report that a meeting of the committee would be held on Dec. 8, 1909.

Under the head of new business, quite a lengthy discussion was had on the establishing of the grade of Honorary Membership in the Society, and, on motion of W. H. Ross, the President was authorized to appoint a committee of five to consider this matter, and also any other amendments to the Constitution and By-Laws that the members may suggest. The motion carried, and President Block appointed Edgar Penney, L. Howard Jenks, Dr. Charles E. Lucke, John E. Starr and Theodore Kolischer on this committee.

There was considerable discussion on amending paragraph B 20 and paragraph B 21 of the By-Laws relative to not printing in the Transactions papers that have not been circulated among the members in advance of the meeting at which they are to be read, and also relative to the publishing of papers without the authority of the Publication Committee. This discussion finally resolved itself into a resolution by H. W. Cole that the President appoint a committee of three to consider these proposed amendments and report at the afternoon session of the meeting. The motion carried and President Block appointed H. W. Cole, John E. Starr and Fred W. Wolf, Jr., on this committee.

On motion of Gardner T. Voorhees, President Block was made

a member of the Committee on Physical Constants that was appointed at the Chicago meeting of the Society. The committee now includes the following members: Dr. Charles E. Lucke, *Chairman;* Dr. D. S. Jacobus, John E. Starr, F. E. Matthews, Gardner T. Voorhees and Louis Block.

A discussion was had on a suggestion of the Council as to the place of holding the Western meeting of the Society in 1911, and, on motion of L. Howard Jenks, the meeting suggested St. Louis, Mo.

Theodore Kolischer moved that paragraph C 26 of the Constitution be so amended that Associate Members be ineligible for the office of president and vice-president of the Society, for discussion at this meeting, and final action and discussion at the sixth annual meeting.

Where paragraph C 26 of the Constitution now reads:

OFFICERS

C. 26. At each Annual Meeting there shall be elected from among the Members and Associates:

A President to hold office for one year.

Two Vice-Presidents, one to hold office for one year and one to hold office for two years. After the first year one Vice-President to be elected annually for a term of two years.

A Treasurer to hold office for one year.

Nine Members or Associates shall be elected to the Council at the first Annual Meeting, three to hold office for one year, three to hold office for two years, and three to hold office for three years, and at each subsequent Annual Meeting three Members or Associates shall be elected, each to serve three years.

Mr. Kolischer would have it read:

OFFICERS

C 26. At each Annual Meeting there shall be elected from among the Members:

A President to hold office for one year.

Two Vice-Presidents, one to hold office for one year and one to hold office for two years. After the first year one Vice-President to be elected annually for a term of two years.

There shall be elected from among the Members and Associates a Treasurer to hold office for one year.

Nine Members or Associates shall be elected to the Council at the first Annual Meeting, three to hold office for one year, three to hold office for two years, and three to hold office for three years, and at each subsequent Annual Meeting three Members or Associates shall be elected, each to serve three years.

The report of the Tellers of Election of Officers was now received. It follows:

REPORT OF TELLERS OF ELECTION OF OFFICERS

NEW YORK, N. Y., December 6, 1909.

Mr. Louis Block, President, The American Society of Refrigerating Engineers, 154 Nassau Street, City.

DEAR SIR:—Your Tellers of Election of Officers beg to report that they

have canvassed the ballots this day and find that one hundred and twelve votes were cast, three of which were void, as the signatures of the voters were not contained on the outer envelopes. The votes cast for officers were as follows:

President—R. H. Tait, 108; Peter Neff, 1.
Vice-President—Charles E. Lucke, 107; Theodore Kolischer, 1; Thomas Shipley, 1.
Treasurer—Walter C. Reid, 109.
Directors—G. T. Voorhees, 109; Charles Dickerman, 109; E. N. Friedmann, 105; Louis Block, 2; Samuel Shipley, 1; Karl Vesterdahl, 1.

We therefore beg to inform you that the following members have been elected to fill the offices falling vacant after this, the fifth annual meeting:

President—R. H. Tait.
Vice-President—Charles E. Lucke.
Treasurer—Walter C. Reid.
Directors—Charles Dickerman, Edward N. Friedmann, Gardner T. Voorhees.

Respectfully submitted,

(Signed) FRED W. WOLF, JR., *Chairman*
JAMES ELY,
FRANK H. ABBEY,
} *Tellers of Election of Officers.*

The President declared the new officers duly elected and appointed ex-Presidents Penney and Starr a committee to escort President-elect Tait to the chair beside him.

President-elect Tait, in accepting the presidency of the Society, said: "I desire to express my sincere thanks to the members of The American Society of Refrigerating Engineers for the honor of making me President of this Society. It is an honor any man ought to be proud of, and I am proud of it. I doubly appreciate the honor because there are so many able and well-known men in the Society to select from. My experience in this line has been small and my knowledge of parliamentary laws limited, but I know I can depend on you for advice and coöperation, and I assure you that I will serve you to the best of my ability and to the best interest of the Society."

The address of President Block was now received with close attention and appreciation. It appears on another page of these Transactions as one of the papers read at this meeting.

The meeting now adjourned for luncheon, arranged for by the Programme Committee.

Second Session, Monday Afternoon, December 6, 1909

The second and last session of the meeting was called to order at about 1.30 o'clock.

The first order of business was the report of the Amendment Committee through Chairman Cole. It follows:

REPORT OF AMENDMENT COMMITTEE

NEW YORK, N. Y., December 6, 1909.

Mr. Louis Block, President, The American Society of Refrigerating Engineers, New York, N. Y.

DEAR SIR:—Your committee on wording a proposed amendment reports the following:

Insert in B 20 at end of third sentence, as new matter:

"No paper intended for publication in the Transactions of the Society shall be read at the meetings of this Society unless a copy of it shall have been mailed to each member in printed or typewritten form at least two weeks before the date of the meeting at which it is expected to be read. It shall be the duty of the Program Committee to cause such copies to be so mailed. This rule shall not apply to lectures or addresses offered by persons invited to deliver them by the unanimous vote of the Program Committee."

Rest of section to remain as now.

And to B 21 add after second sentence, as new matter:

"No paper shall be published or authorized to be published, either publicly or privately, purporting to be a part of the Transactions of the Society, without the authority of the Publication Committee.

Rest of section to follow as now.

Respectfully submitted,

(Signed) HAROLD W. COLE, *Chairman.*
JOHN E. STARR,
FRED W. WOLF, JR.
} *Amendment Committee.*

The proposed amendments in detail are as follows:

Where paragraph B 20 of the By-Laws now reads:

PROGRAM COMMITTEE

B 20. The President shall appoint a committee from members of the Council who shall procure professional papers, to pass upon their suitability for presentation, and to suggest topical subjects for discussion at the meetings. The committee may refer any paper presented to the Society to a person or persons, especially qualified by theoretical knowledge or practical experience, for their suggestions or opinions as to the suitability of the paper for presentation. Papers from non-members shall not be accepted except by unanimous vote of the committee. The committee shall arrange the programme of each meeting of the Society, and shall have general charge of the entertainments to be provided for the members and guests at each meeting. It shall prohibit the distribution or exhibition at the headquarters or at the meeting places of the Society of all advertising circulars, pamphlets or samples of commercial apparatus or machinery. At the end of each fiscal year the committee shall deliver to the Secretary for presentation to the Council a detailed report of its work.

The committee would have it read:

PROGRAM COMMITTEE

B 20. The President shall appoint a committee from the members of the Council who shall procure professional papers, to pass upon their suitability for presentation, and to suggest topical subjects for discussion at the meetings. The committee may refer any paper presented to the Society to a person or persons, especially qualified by theoretical knowledge or practical experience, for their suggestions or opinions as to the suitability of the paper for presentation. Papers from non-members shall not be accepted except by unanimous

vote of the committee. No paper intended for publication in the Transactions of the Society shall be read at the meetings of this Society unless a copy of it shall have been mailed to each member in printed or typewritten form at least two weeks before the date of the meeting at which it is expected to be read. It shall be the duty of the Program Committee to cause such copies to be so mailed. This rule shall not apply to lectures or addresses offered by persons invited to deliver them by the unanimous vote of the Program Committee. The committee shall arrange the program of each meeting of the Society, and shall have general charge of the entertainments to be provided for the members and guests at each meeting. It shall prohibit the distribution or exhibition at the headquarters or at the meeting places of the Society of all advertising circulars, pamphlets or samples of commercial apparatus or machinery. At the end of each fiscal year the committee shall deliver to the Secretary for presentation to the Council a detailed report of its work.

Where paragraph B 21 of the By-Laws now reads:

PUBLICATION COMMITTEE

B 21. The Publication Committee shall consist of three members of the Council appointed for a term of one year. The committee shall review all papers and discussions which have been presented at the meetings, and shall decide what papers and discussions, or parts of the same, shall be printed. At the end of each fiscal year the committee shall deliver to the Secretary for presentation to the Council a detailed report of its work.

The committee would have it read:

PUBLICATION COMMITTEE

B 21. The Publication Committee shall consist of three members of the Council appointed for a term of one year. The committee shall review all papers and discussions which have been presented at the meetings, and shall decide what papers or discussions, or parts of the same, shall be printed. No papers shall be published or authorized to be published, either publicly or privately, purporting to be a part of the transaction of the Society without the authority of the Publication Committee. At the end of each fiscal year the committee shall deliver to the Secretary for presentation to the Council a detailed report of its work.

The Resolutions Committee, appointed at the Chicago meeting of the Society, offered the following resolutions through John E. Starr, and they were accepted and copies of the resolutions were ordered spread on the minutes of the meeting and copies sent to the families of the deceased members:

HENRY BLETHEN.

The American Society of Refrigerating Engineers has learned with profound regret of the death of its member, Henry Blethen, of the State of Washington.

His thoughtful, thorough and painstaking work as a refrigerating engineer, as well as his pleasing personality, have been most fully understood and appreciated by those of us who knew him best.

The American Society of Refrigerating Engineers has indeed lost a valued member who has ably represented it in the Far West.

It is ordered that this resolution be made a part of the records of the Society and a copy be sent to his family.

FRANCIS H. BOYER.

On February 21, 1909, Francis H. Boyer, a member of this Society, died at his home in Somerville, Mass. He was another of that band of pioneers in the refrigerating field, the members of which, to the grief of the Society, dwindle from year to year, but to whose memory all honor is due.

Francis H. Boyer was born in 1845 at Manheim, N. Y. He was of an essentially mechanical turn of mind and in the '70's he took up the study of refrigeration. The trade was then in its earliest infancy, and it fell to him to build and cool the first rooms on a steamer sailing from New York to carry beef to England. Later he was superintendent in charge of brewery installations for the firm of De La Vergne & Mixer. For them he installed the first refrigerating machine used in the city of Boston, which was put in a brewery in 1884. In 1890 he went with the Squires Company, of Boston, and remained as mechanical superintendent for them until 1900. Then with his son he went into business as a consulting refrigerating engineer.

Mr. Boyer was a member of The American Society of Mechanical Engineers, having been for three years a director of that body; the Boston Society of Civil Engineers; honorary member of the National Association of Stationary Engineers, and for two years was president of the Somerville Board of Trade.

It is with great sorrow that The American Society of Refrigerating Engineers records his death and extends its warmest sympathy to his family.

It is ordered that this resolution be spread upon the minutes of the meeting and a copy be sent to the family of our late friend and member.

ALFRED SIEBERT.

With a feeling of profound sorrow The American Society of Refrigerating Engineers records the death of another of its members, Alfred Siebert, who died in St. Louis, Mo., on July 20, 1909. His efforts in the field of mechanical refrigeration were many and of permanent value. He was a man of splendid attainments, and as such the members of this Society will always remember him.

The members of the Society at their annual meeting, December 6, 1909, have ordered that this expression be spread upon the minutes and a copy of it be sent to the family of Mr. Siebert.

J. F. Nickerson was now called on to tell of the purposes and scope of the American Association of Refrigeration, the American branch of the International Association of Refrigeration. In the course of his remarks he stated that a commission of the International Association of Refrigeration was preparing a technical lexicon of refrigeration terms in English, French, German and Ido and that the American Association of Refrigeration had been requested to designate the personnel of the American section of the commission that is preparing this lexicon, and that he felt that The American Society of Refrigerating Engineers was deeply interested in this international movement, and that he was authorized to request The American Society of Refrigerating Engineers to suggest two of

its members to serve on the American section of this commission, and he moved, and it was duly seconded, that the appointing of two members be referred to the Council, with power to act. The motion carried.

The reading and discussion of papers was now taken up. The following papers were read:

"Standardizing of Measuring Instruments," James Ely, New York, N. Y., and "Advantages and Limitations of the Flooded System," Dr. H. J. Krebs, Newport, Del.

Dr. Charles E. Lucke also made a few remarks on "The Economy of Wet versus Dry Compression and Its Dependence on the Properties of Saturated Ammonia Vapors."

Before adjourning, Junius H. Stone moved a vote of gratitude and appreciation to President Block for the ability and courtesy with which he had handled the affairs of the Society during his term of office. The motion was unanimously carried.

The meeting then adjourned.

MEMBERS AND GUESTS ATTENDING MEETING.

Abbey, Frank H., Arlington, Mass.
Austin, A. O., Milwaukee, Wis.
Bates, Guy, New York, N. Y.
Bavier, R. N., New York, N. Y.
Bavier, W. N., New York, N. Y.
Block, Louis, New York, N. Y.
Borgstedt, H. N., Yonkers, N. Y.
Bower, W. H., Philadelphia, Pa.
Brandt, C., New York, N. Y.
Briggs, J. N., Coeymans, N. Y.
Burhorn, Edwin, New York, N. Y.
Cole, Harold W., New York, N. Y.
Conners, S. P., New York, N. Y.
Cooper, Madison, Watertown, N. Y.
Daly, Benjamin F.,
Rockaway Beach, N. Y.
Dannenbaum, H., Philadelphia, Pa.
Day, A., Bloomfield, N. J.
Dickermann, Charles,
Philadelphia, Pa.
Dixon, H. M., New York, N. Y.
Doelling, L., New York, N. Y.
Ely, James, New York, N. Y.
Fitzsimmons, J. E., New York, N. Y.
Frick, Ezra, Waynesboro, Pa.
Friedmann, E. N., New York, N. Y.
Goerner, G. W., New York, N. Y.
Greene, Van R. H., New York, N. Y.
Guckel, C. H., Colon, Panama.
Hexamer, W. E., Philadelphia, Pa.
Hill, Walter L., Boston, Mass.
Holden, D. L., New York, N. Y.
Hoos, William, Philadelphia, Pa.
Howe, Arthur E., New York, N. Y.
Jamison, Jr., J. V., Hagerstown, Md.
Jacobus, D. S., New York, N. Y.
Jenks, L. Howard, New York, N. Y.
Kehoe, Robert P., New York, N. Y.
Kelly, A. W., Red Bank, N. J.
Kolischer, T., Philadelphia, Pa.
Krebs, H. J., Wilmington, Del.
Lewis, E. W., Cincinnati Ohio.
Lucke Charles E., New York, N. Y.
Mallon, M. F., New York, N. Y.
Marshall, A. T., Hartford, Conn.
Marshall, H. H., Hartford, Conn.
Matthews, F. E., New York, N. Y.
May, W. J., New York, N. Y.
McDoal, Grant, New York, N. Y.
Nesbett, A., New York, N. Y.
Nickerson, J. F., Chicago, Ill.
Nulsen, H. S., New York, N. Y.
Parsons, W. Everett, Newark, N. J.
Penney, Edgar, Newburgh, N. Y.
Phelps, S. R., New York, N. Y.
Phillips, E. L., New York, N. Y.
Plock, John L., New York, N. Y.
Randall, W. E., New York, N. Y.
Reilly, J. P., New York, N. Y.
Reitze, G., New York, N. Y.
Rooksby, E. J., Philadelphia, Pa.
Ross, W. H., New York, N. Y.
Scott, J. W., New York, N. Y.
Shipman, R. L., Ithaca, N. Y.
Smith, Guy B., Brooklyn, N. Y.
Sparks, John C., New York, N. Y.
Starr, John E., New York, N. Y.
Stone, J. H., New York, N. Y.
Tait, R. H., St. Louis, Mo.
Taylor, E. C., Rochester, N. Y.

Thomas, J. H., New York, N. Y.
Thompson, M. W.,
Greensboro, N. C.
Vesterdahl, Karl, New York, N. Y.
Voorhees, G. T., New York, N. Y.
Warner, Irving, Wilmington, Del.
Wegemann, Karl, New York, N. Y.
Weintraub, W. M., Philadelphia, Pa.
Werliin, L., Philadelphia, Pa.
White, E. H., Bridgeport, Conn.
Wittemann, J. F., New York, N. Y.
Wittemann, R. W., New York, N. Y.
Wolf, Jr., Fred W., Chicago, Ill.
Wright, George W., Baltimore, Md.
Yeakley, L. F., Philadelphia, Pa.
Young, Conrad H., New York, N. Y.

THE BANQUET.

The American Society of Refrigerating Engineers held its banquet in the Hotel Victoria, Broadway and Twenty-seventh street, on Monday evening, December 6th, with an attendance of about seventy-five. An excellent menu was enjoyed by all.

Ex-President John E. Starr acter as toastmaster and addresses were made by President R. H. Tait, ex-President Louis Block, Dr. Charles E. Lucke, ex-President W. Everett Parsons, Gardner T. Voorhees, Daniel L. Holden and ex-President Edgar Penney. John H. Thomas, New York, N. Y., entertained those present with some of his sweet songs and Conrad H. Young, New York, N. Y., told some of his always enjoyable dialect stories.

The following attended the banquet:

Abbey, Frank H., Arlington, Mass.
Bates, Guy, New York, N. Y.
Bavier, R. N., New York, N. Y.
Bavier, W. N., New York, N. Y.
Block, Louis, New York, N. Y.
Borgstedt, H. N., Yonkers, N. Y.
Bower, W. H., Philadelphia, Pa.
Brandt, Carl, New York, N. Y.
Connors, S. P., New York, N. Y.
Dannenbaum, H., Philadelphia, Pa.
Dickerman, Charles, Philadelphia, Pa.
Dixon, H. M., New York, N. Y.
Doelling, L., New York, N. Y.
Ely, James, New York, N. Y.
Fitzsimmons, J. E., New York, N. Y.
Goerner, G. W., New York, N. Y.
Greene, V. R. H., New York, N. Y.
Guckel, C. H., Colon, Panama.
Hexamer, William E.,
Philadelphia, Pa.
Hill, Walter L., Boston, Mass.
Holden, D. L., New York, N. Y.
Howe, Arthur E., New York, N. Y.
Kehoe, Robert P., New York, N. Y.
Kolischer, Theodore,
Philadelphia, Pa.
Krebs, H. J., Newport, Del.
Lucke, Charles E., New York, N. Y.
May, W. J., New York, N. Y.
Marshall, A. T., Hartford, Conn.
McDoal, Grant, New York, N. Y.
Nesbett, A., New York, N. Y.
Nickerson, J. F., Chicago, Ill.
Nulsen, Herbert S.,
New York, N. Y.
Parsons, W. Everett, Newark, N. J.
Penney, Edgar, Newburgh, N. Y.
Randall, W. F., New York, N. Y.
Reilly, J. P., New York, N. Y.
Rooksby, E. J., Philadelphia, Pa.
Ross, W. H., New York, N. Y.
Scott, J. W., New York, N. Y.
Shipman, R. L., Ithaca, N. Y.
Smith, Guy B., Brooklyn, N. Y.
Starr, John E., New York, N. Y.
Tait, Roderick H., St. Louis, Mo.
Taylor, E. C., Rochester, N. Y.
Thomas, John H., New York, N. Y.
Thompson, M. W.,
Greensboro, N. C.
Vesterdahl, Karl, New York, N. Y.
Voorhees, Gardner T.,
New York, N. Y.
Wegemann, Karl, New York, N. Y.
Weintraub, W. M., Philadelphia, Pa.
Werliin, L., Philadelphia, Pa.
Wolf, Jr., Fred W., Chicago, Ill.
Wright, George W., Baltimore, Md.
Yeakley, L. F., Philadelphia, Pa.
Young, C. H., New York, N. Y.

PAPERS OF THE

FIFTH ANNUAL MEETING

OF

THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS

No. 77.

PRESIDENTIAL ADDRESS—FUEL ECONOMY AND HOW TO ATTAIN IT.

By Louis Block, New York, N. Y.

I take it to be the privilege of the President of this Society to make suggestions in his address in the line of what, in his judgment, he considers improvements in the art which we represent or are connected. Papers read at these meetings should deal with facts, not speculation, and they should convey positive information, while the President's address may suggest lines of thought to be acted upon by the individual if he so elects.

At Chicago I spoke of cost reduction of ice making plants and to-day I call attention to fuel economy and how to attain it.

Ever since Twining built his first compression machine in New Haven, ever since Carré built his first absorption machine in Paris, refrigerating engineers have struggled to improve the machines in order to obtain more economical results. They have striven to improve the compressor and have worked to improve the absorber, and they have succeeded to such an extent that there is but small room for improvement left. Nearly all the energy has been applied to but a small portion of the entire power plant, and perhaps naturally so, because that which produced refrigeration was constantly uppermost in the mind of the refrigerating engineer and he worked earnestly and diligently to improve the efficiency of the refrigerating machine.

He neglected the efficiency of the steam engine, the steam generator, the furnace, the stoker and the coal pile, and, with a high compressor or absorber efficiency, the combined efficiency of the plant, in most instances, remained below the average.

The steam engines used to-day for compressor drive are, as a rule, of a recognized standard and as efficient as they can be made without cumbersome complications.

Internal combustion engines may be used for driving ammonia compressors; there are a few very creditable installations in this country which yield highly economical results, and we may look forward to the more general application of this class of prime mover in the near future. With the development and introduction of high-

speed compressors, the internal combustion engine will become more available and even desirable for compressor drive.

Gas producers are far from perfect, but, as long as the old fields yield a product which may be burned with economy in the motor cylinder of an engine, and as long as new oil fields are discovered every year, why should we worry about the unreliability for continuous operation of the gas producer?

A great number of compressors will always be driven by steam engines, especially those which form part of a can ice making plant, and in this connection, and in connection with absorption machines, boiler-room efficiency will always play an important part.

Steam generator design and construction have received a great deal of intelligent attention and there is not much, if any, room for improvement, but the furnace, the stoker, whether he be flesh and blood or of the mechanical kind, and the coal pile, have been much neglected by refrigerating engineers. To ascertain furnace efficiency an evaporation test of the steam generator is usually made. The evaporation in a boiler depends upon the kind of boiler and upon its condition at the time of test, and is only distantly related to furnace efficiency. If the evaporation is low, it may be due to the boiler, the furnace, the fireman or the coal.

The furnace must stand alone and must be examined and tested without relation to the steam generator. The function of the furnace is to convert the heat energy of the coal into available form and the boiler function is to take the heat energy delivered to it and use it in the production of steam.

The economical combustion of fuel is therefore a most important subject. The losses due to careless handling of the furnace may amount to many times the losses due to careless operation of the refrigerating machines.

We must take a deeper interest in combustion of fuel; we must pay more attention to the boiler room.

The application of flue gas analysis has not received the attention which is its due.

When, about a year ago, I asked the inventor of a CO_2 recorder, whose patent covering the invention was dated 1895, why he had not introduced his apparatus at that time, he answered by saying: "At that time it wasn't generally understood whether CO_2 was to be eaten with a spoon or worn on the hat." Flue gas analyses were very seldom made and a practical automatic CO_2 recorder is an instrument which has only been in use for the past few years. The flue gas analysis helps us to determine whether there is air leakage, and after

the cracks have been stopped up it will tell us whether there is seepage of air through the bricks of the boiler walls into the furnace. Bricks are porous and, unless the boiler walls are insulated or the bricks painted, air will pass through them into the furnace.

Gas analysis will tell us whether there is too much or not enough draft; it will prove to us that generally the least draft that may be employed to carry the load is the best for general economy. It will, on the other hand, prove the fallacy of that proposition in the case of excess of grate surface for the load, by showing a high percentage of CO in the flue gases.

A draft gauge and a CO_2 instrument will determine for us the proper draft to be employed. It will help us also to determine whether it is best to regulate the draft by the ashpit doors or the damper.

Shall the fires be thick or shall they be thin? If the latter, too much air may pass through the thin layer of burning coal into the furnace; if too thick, especially when coal is first thrown into the furnace, and if it is bituminous coal, a great volume of combustible gas will result. The demand for air is greatest at this time, when the least can pass through the fuel bed; then the fire burns down, the demand for air diminishes, while the supply automatically increases as the fuel bed becomes thinner. The CO_2 instrument will determine which method is preferable, and it will tell us whether frequent light firing, with its furnace doors open a large part of the time and the consequent inrush of air, or heavy firing at greater intervals, is the best. It will tell us whether it is advantageous to wet the coal, whether steam jets should be used, whether the grate best adapted to the fuel conditions is used and whether the grate surface is too large or too small.

The losses due to careless or ignorant furnace management may amount to from 20 to 25 per cent., while with bare spots on the grate near the bridgewall the losses may amount to 50 per cent., owing to the enormous excess of air entering the combustion chamber.

The question to be determined is—are we burning the fuel with the least surplus of air? As tersely put by a fuel expert: "That furnace is the most efficient which completely consumes the combustible with the least surplus of air."

The coal pile is of the utmost importance in bringing about plant economy. In nine out of ten cases to-day coal is bought because it is cheap, or it is free burning, or because it does not clinker as much as others. Coal should be bought upon a B. t. u. basis and the strictest guarantee. If the coal is changed without notice and fur-

nace operation has remained the same, a CO_2 recorder or hand instrument will indicate it and a coal analysis should then be resorted to, to determine in what degree the quality of the coal has changed.

The fireman or mechanical stoker needs looking after. Does the former always obey instructions? Is the distribution of coal over the grate surface of the mechanical stoker such as not to leave occasional bare spots? These are all matters which require the most earnest attention of the engineer.

The coal pile, the fireman, the furnace, the boiler and the refrigerating machine all are intimately related, and only by good engineering in the design of boiler room equipment as well as good engineering in the design of the refrigerating machine and plant, and intelligent management and operation of the whole, can we obtain that economy for which we are all so earnestly striving.

No. 78.

STANDARDIZING OF MEASURING INSTRUMENTS.

By James Ely, New York, N. Y.
(Associate Member of the Society)

I will confine myself in this paper to the instruments with which I am most familiar and which, I believe, to be best adapted to the uses of the members of The American Society of Refrigerating Engineers.

Those which I have selected are as follows:

Thermometers, mercury and electric,
Hydrometers,
Hygrometers,
Anemometers.

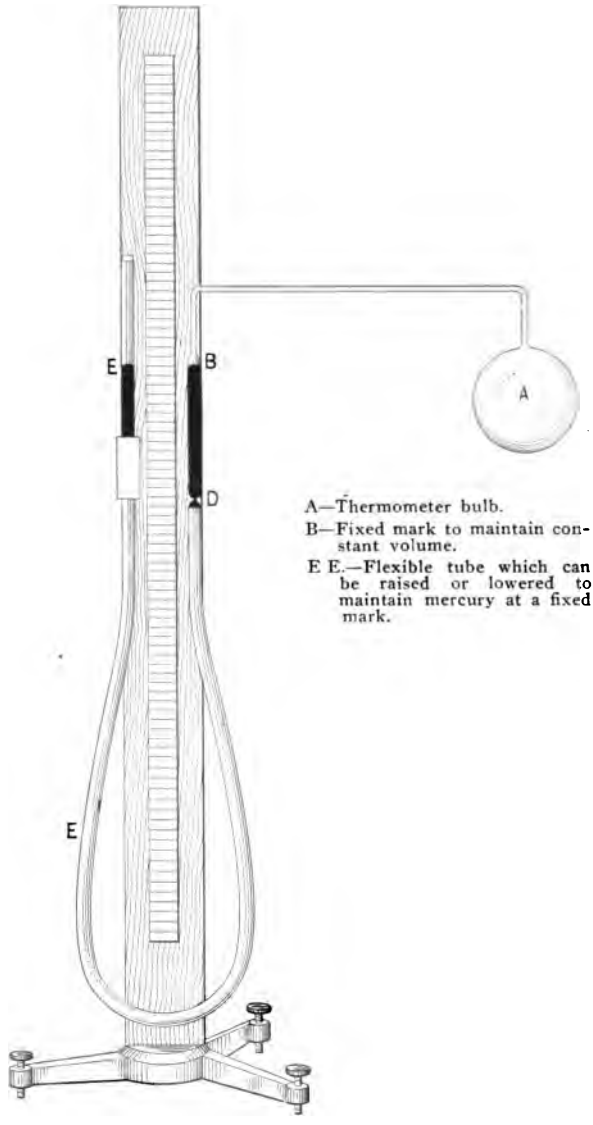
The National Bureau of Weights and Measures defines the hydrogen gas thermometer as the standard, which is a constant volume of hydrogen gas at an initial pressure of one meter of mercury with the Centigrade scale, the scale of which reads zero for the temperature of melting ice, and 100 for the temperature of the vapor of distilled water boiling at atmospheric pressure. This thermometer is the foundation upon which rests all temperature measuring instruments. Being complicated and delicate, it is not adapted to any other purpose than to harmonize the different temperature measurement standards of the nations of the world.

Practically and commercially speaking, a standard thermometer is one whose scale is in accord with that of a hydrogen gas thermometer graduated in degrees, sub-divided fine enough to read with precision and is made of those materials most likely to remain constant.

When either the ice-point or boiling-point scale is upon the thermometer, changes in the position can be noted, and any change applies equally throughout the entire scale. Working standards must be tested frequently at the ice or boiling-points.

MERCURY THERMOMETERS

A standard thermometer whose scale is in accord with that of the hydrogen gas thermometer when originally made, unless properly seasoned, will not remain constant. The higher the thermometer



SIMPLE FORM OF GAS THERMOMETER, SHOWING HOW CONSTANT VOLUME MAY BE MAINTAINED BY RAISING OR LOWERING TUBE.

indicates and is exposed to such indications, the greater will be the change, but thermometers used at low temperatures will change unless the tubes are properly treated.

When making thermometers that will agree with standard instruments, we must take into consideration how such thermometers are to be used. For instance, taking the usage of a brine pipe thermometer into consideration, the manufacturer, before making the scale, attaches the thermometer to a brine pipe; then taking the temperature of the brine with a standard thermometer fully immersed, gives the point to which the mercury column has risen in the brine pipe thermometer tube the same value as is indicated by the standard.

For testing work all glass-stem thermometers should be used, the scales of which are graduated for a fixed condition, so they can be used in a mercury well, say 3 inches deep, and give correct readings, although 10 inches of the column is not immersed.

ELECTRICAL THERMOMETERS

We will consider only the platinum resistance form of electrical thermometer.

In standardizing this instrument the same fundamental points are used as in a mercury thermometer; that is, melting ice and boiling water under standard conditions. For intermediate and other points, a standard mercury thermometer is used.

Platinum is chosen as the resistance material because it is non-corrosive, can be obtained of high purity and, therefore, can be regularly reproduced in all its qualities.

We measure temperatures by measuring the change in electric resistance undergone by a coil of platinum wire. Suitable leads are connected between the bulb or sensitive portion subjected to the temperature to be measured and the indicating instrument, either direct reading or recording. The actual measurement can be transferred to any required distance. By means of compensating leads the measurement is made independent of the distance separating the bulb and the measuring instrument, also of any temperature change suffered by this connecting cable. Thus, the only temperature change which can affect the reading is a change in the temperature of the bulb or platinum coil.

The indicating or recording instrument, although its operation is one of measuring electrical resistance, is arranged so that this measurement is automatically translated into a temperature reading.

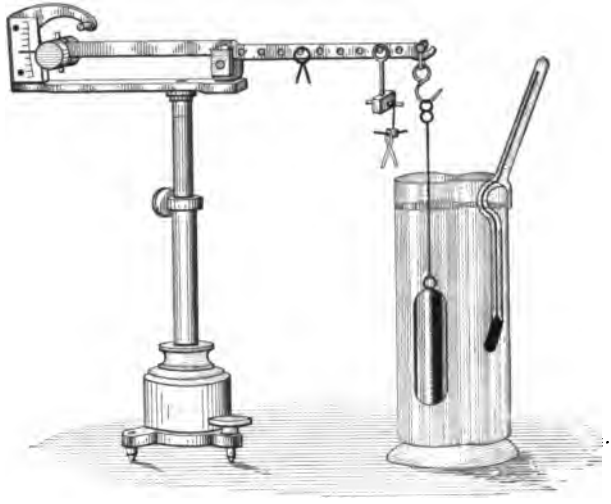
The great advantage of the platinum resistance thermometer is the possibility of measuring accurately small differences of tem-

perature. This is accomplished by adjusting the change in the resistance so the scale can be made to any desired openness by increasing the sensitiveness of the measuring apparatus or increasing the amount of resistance wire in the bulb so as to get a large effect for very small changes in temperature.

HYDROMETERS

The standard instrument for determining the specific gravity of any liquid is the balance scale and the specific gravity bottle which holds a definite volume of distilled water at a temperature of 60 degrees Fahr. Such instruments are more suitable for laboratory work than commercial use.

The commercial standard hydrometer is made of glass with easy sloping lines, so the liquid may enter smoothly and not trap air



WESTPHAL'S ORIGINAL PATTERN SPECIFIC GRAVITY BALANCE FOR LIQUIDS.

bubbles on the surface of the glass. The instrument consists of what is known as its stem and a floating bulb. Introduced in the floating bulb is a weight, either mercury or shot, the scale being marked according to the weight of the bulk of the liquid displaced by the floating body, and it is used to determine the relative density of liquids, pure water being used at a temperature of 60 degrees Fahr. as the standard of comparison. This scale is called the Specific Gravity Scale, and the initial point is marked 1.000. A liquid whose density is 50 per cent. greater than water would read 1.500 and one whose density is 25 per cent. lighter than water would read .750 upon the scale.

Hydrometers graduated with the specific gravity scale or any of its modifications, such as Twaddles, are directly comparable with the specific gravity bottle and balance, and if the standard conditions of correct temperature, correct balance, pure water, clean glasses and accurately measured bottles are maintained, there need be no disagreement between different observers to as far as the third decimal place, but for instruments of practical size beyond the third decimal place, personal equation errors are such that any one authority issuing a certificate of error to the fourth decimal or beyond, should do so only when he acknowledges that the certificate is subject to a reasonable construction. Few hydrometers are scaled with the specific gravity scale; most of them have arbitrary scales, such as Beaumé's, Brix's and Balling's and many minor ones.

The United States Bureau of Standards in its attempt to harmonize, as far as possible, the world's different bureaus covering the standard value of the arbitrary hydrometer scales, up to the present time has only positively determined the values covering the Beaumé scale.

The Manufacturing Chemists' Association of the United States agreed upon the specific gravity value of the Beaumé scale and, when the subject was before the United States Bureau of Standards for determination, it accepted the Manufacturing Chemists' Association's value on the ground that this Association's influence was dominant in this country.

Brix's scale is made to suit the requirements of one company, the values having been determined for them by the United States Department of Agriculture, Bureau of Chemistry, but, as this does not suit some of the other sugar manufacturing interests, we then work from sample instruments submitted, or else they must give us their determination of Brix's scale in specific gravity values.

Balling's scale we make to agree with the German Bureau of Standards at Charlottenburg; but this does not suit the requirements of the brewers' schools in this country, and in these instances we do as mentioned for the Brix scale.

If custom has fixed upon one value to a greater extent than upon another, on the less known scales, we work accordingly and make up the scales as the majority of interests have determined, but do so knowing that there are in use other arbitrary scales bearing the same name, but of different specific gravity values.

In the instruments used by the refrigerating engineers we find the Beaumé, heavy and light, calcium chloride with the salometer scale, 0 to 120, and what is known as the "Salt Per Cent" scale, 0 to 100. These are equally in a chaotic condition.

It would be well for us as manufacturers and users of hydrometers if all of the associated bodies using hydrometers would have their chemists determine the value of the instruments peculiar to their interest, and then without a doubt their determinations would be standardized by the Bureau of Standards.

HYGROMETERS

Scientifically speaking a standard hygrometer would be a dew-point apparatus. A description of a good type is as follows, copied from "Meteorology," by Thomas Russell:

> A dew point apparatus consists of a thin brass tube 1 inch in diameter, 6 inches long, silvered or gilded on the outside.
>
> A thermometer fitted into a cork or rubber stopper has its bulb inside the tube with the stem projecting. A quantity of some volatile liquid, as ether, is contained in the tube so as to cover the thermometer bulb. Openings in the cork contain tubes, one of which dips into the liquid, the other has its end some distance above the surface of the liquid.
>
> By means of these tubes a current of air is blown through the liquid and evaporation induced, which lowers the temperature of the liquid and the tubes containing it.
>
> When the temperature of the dew point is reached, a film of moisture forms on the polished surface of the tube. The temperature then shown by the thermometer is that of the dew point of the air.

The dew-point apparatus is undesirable for commercial purposes on account of the inconvenience of its use and expense of the liquids; at the same time it is indispensable, for it is with this instrument that we are able to get the relative humidities that would be impossible with a more simple instrument; it is also used for the standardizing of commercial hygrometers.

A standard commercial hygrometer is recognized by the United States Government and is referred to in Weather Bureau Pamphlet 235, entitled "Psychrometric Tables," which we recognize as the standard tables.

This instrument is best explained by describing the sling psychrometer, which consists of a pair of thermometers fastened to a scale and provided with a handle, which permits the thermometers to be whirled rapidly, the bulbs thereby being strongly affected by the temperature of the air and its moisture. The bulb of one thermometer projects beyond the other and is covered with a thin clean muslin, which is to be wet at the time the observation is made.

Other hygrometers of the wet and dry bulb type, if accurate, will give correct readings if placed in an air current of at least 600 feet per minute. This is necessary, as the psychrometer tables are based on air in motion.

In making observations with a hygrometer, great care should be

used. Note first the reading of the dry bulb and be sure you get the lowest reading, as the thermometer will drop from a half to one and a half degrees when placed in the air current. Wet the muslin-covered bulb with water as near the air temperature as possible, then expose the thermometers again to the air current and note the readings. Read as before, the dry bulb first, repeating this until you get two consecutive readings alike.

The instrument is very simple, but few understand the subject of humidity.

Water vapor is held in suspension in greater or lesser amounts as the temperature of the space occupied by the vapor is increased or diminished.

A cubic foot of space at a temperature of 30 degrees Fahr., holding 1.9 grains of water vapor in suspension, is holding all of such vapor that it can hold and is said to be saturated, the relative humidity being 100 per cent.

The same space heated to 90 degrees Fahr. and holding the same amount of water (1.9 grains) is holding in such suspension only 15 per cent. of what it could hold for this 90 degree temperature, as the air at that temperature will hold 14.8 grains of water, or about seven times as much.

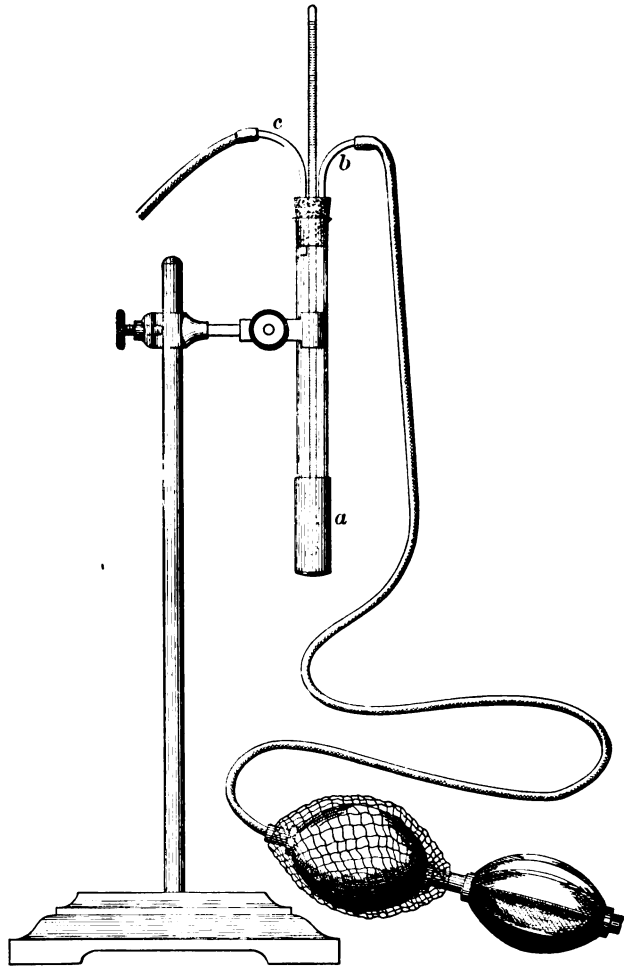
Absolute humidity is the amount of water by weight that is held in suspension and is expressed in grains per cubic foot; relative humidity is the relation of water actually in suspension to what might be in suspension if the space were saturated, and is expressed in per cent.

For example: At 30 degrees Fahr., if the relative humidity is 78 per cent., 22 per cent. more water could be added before the saturated or dew-point would be reached.

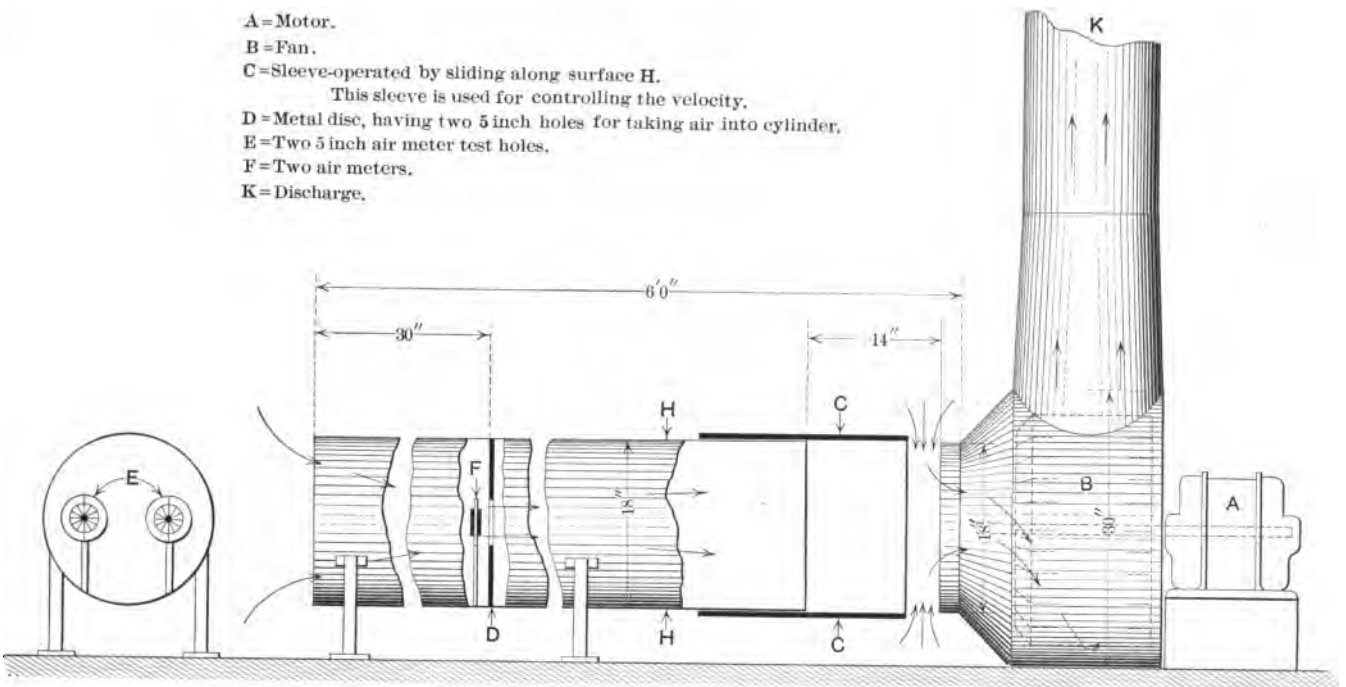
ANEMOMETERS

We accept the Kew Observatory of England as authority and depend on instruments certified by them to check and certify our own manufactured goods with the speed up to 5,000 feet per minute, that being as high as they will certify; but as we manufacture instruments registering up to 10,000 feet per minute, we use the same apparatus checking against the speed of the blower. A description of a testing apparatus is as follows:

A long tight box is used. At one end is a fan for drawing the air, at the far end slides of the proper size having a hole in the center, according to the size of the instrument to be tested, are put in place. Glass windows are inserted in the box so the operator may



DEW-POINT APPARATUS.


A=Motor.
B=Fan.
C=Sleeve-operated by sliding along surface H.
This sleeve is used for controlling the velocity.
D=Metal disc, having two 5 inch holes for taking air into cylinder.
E=Two 5 inch air meter test holes.
F=Two air meters.
K=Discharge.
6′0″
30″
14″
K
H
C
F
E
B
A
D
H
C

ANEMOMETER.

at all times note the instrument, which is placed carefully in the channel about 12 inches from the opening, and after a minute has elapsed, registered by a stop-watch, the reading of the instrument is noted.

The one to be checked is placed in the current in exactly the same position and the same test is made. By an alteration in the pitch of the fan blades the instrument can be made to run fast or slow, and is adjusted to agree with the standard instrument as near as possible. A correction sheet is then made up showing the correction curve.

Anemometers are made both with their fans facing the current and their dials facing the current, and they should always be used in the position for which they were manufactured, as the correction curve will vary if used otherwise.

DISCUSSION.

Fred W. Wolf, Jr.—I would like to ask Mr. Ely about how accurate is the average thermometer that is bought in the open market—say the kind that is kept in stock in drug stores?

James Ely.—That is a very hard question to answer, Mr. Wolf. It might be very good and it might be just as bad.

Fred W. Wolf, Jr.—Have you ever seen six degrees variation?

James Ely.—Yes; more.

Charles E. Lucke.—And I have seen them absolutely right.

Fred W. Wolf, Jr.—Where would the variance be—around a temperature of, say, 30 or 32 degrees and below that?

James Ely.—It would be hard to tell. It would depend on the character of the instrument. Engineers do not seem to realize that the character of the instrument varies. Some manufacturers can make good goods—a thermometer of precision. Still, when you ask a man $18 for a little piece of glass, which in itself is not worth much, it is very hard work to persuade that man that there is a great deal of work in that thermometer, especially when he sees another thermometer for fifty cents, which contains practically the same material. He will usually purchase the fifty-cent thermometer and take a chance along with it.

Fred W. Wolf, Jr.—Can one buy an accurate thermometer? Is it on the market?

James Ely.—Why, certainly.

Fred W. Wolf, Jr.—How are the hollows of those tubes made? Are they ground or just blown?

James Ely.—Blown.

Fred W. Wolf, Jr.—You take the reading from high to low, and then how do you graduate the thermometer?

James Ely.—It depends entirely on the grade of the goods.

Fred W. Wolf, Jr.—Take the best thermometers.

James Ely.—The best thermometers are graduated from test points sufficiently close so that we are sure there is no chance for error in between those test points.

Fred W. Wolf, Jr.—How many would there be between 32 and 212?

James Ely.—In a standard thermometer of precision?

Fred W. Wolf, Jr.—Yes.

James Ely.—Well, that is a very poor scale for a standard thermometer, because you would not get very good readings. I would say every 10 degrees, off-hand.

H. J. Krebs.—Are the platinum thermometers you speak about the same as the platinum-rhodium thermometers?

James Ely.—You mean the resistance thermometers?

H. J. Krebs.—Yes.

Charles E. Lucke.—When there are two metals welded the combination is a thermo-electric couple.

H. J. Krebs.—There are thermometers made with a combination of platinum and rhodium wire. When they are exposed to heat, the degree of heat is measured by the difference of the voltage of that couple. You call the thermometer you speak about a resistance thermometer?

James Ely.—When two wires are used it is a thermo-couple. It measures really the flow of the electric current.

H. J. Krebs.—The one you speak of is not the platinum-rhodium couple?

James Ely.—No.

H. J. Krebs.—To what temperatures are they suitable?

James Ely.—They are suitable for any temperature, I would say, up to 2,300 degrees Fahrenheit.

H. J. Krebs.—And the electric current is supplied from an outside source of low voltage?

James Ely.—The dry cell batteries are in the box with the indicator.

H. J. Krebs.—If you have a large plant, you only would have to put in different platinum points?

James Ely.—If you have ten rooms you would require ten bulbs, each connected by a wire to a switchboard, and one indicator.

H. J. Krebs.—Where can they be secured?

Charles E. Lucke.—The Cambridge Scientific Instrument Company.

Karl Vesterdahl.—I would like to ask Mr. Ely to explain to us how the humidity of air is found below the freezing point, where the wet bulb is out of the question, or rather, how the figures in our handbooks are arrived at which give the humidity below the freezing point?

James Ely.—Well, I will answer that question by reading part of a letter from Professor Marvin, of the Bureau of Standards, Washington, D. C., and you can take it for what it is worth:

"For observing below freezing point of water a cloth-covered bulb is dipped into water as near 32 degrees as may be practicable to obtain and then rapidly whirled. This gives a thin coating of ice on the so-called wet bulb, and the evaporation of this ice gives the temperature required for determining the relative humidity for that particular observation, using the tables as for temperatures above 32 degrees Fahrenheit."

John E. Starr has experimented, to my positive knowledge, more than anyone else on just those lines.

John E. Starr.—I cannot refrain from saying a word or two on this very interesting subject. I think that any cold storage man, or man who is at all acquainted with the subject of the psychrometer, will tell you that when he gets down to the temperature of his egg rooms or apple rooms, or anywhere from 29 to 32 or 33 degrees Fahr., that he cannot get anything out of the psychrometer at all. The reasons are many. In the first place, if a man takes a sling psychrometer into a comparatively dry room, it takes some little time to get the readings. Mr. Ely has stated that you should sling that psychrometer until you get two readings alike. I think that was a little joke of Mr. Ely's. I have never been able—and I have slung a good many sling psychrometers—in a room at 30 degrees Fahr. to get two readings alike. The apparent moisture went up readily. The reason for it, it seems to me, is pretty plain. The body, of course, is exhaling moisture all the time, and necessarily you must sling this thermometer comparatively close to your body. The emanations of moisture from your body alone will give you a constantly increasing degree of humidity at that point. The air where you stand may be quite moist, while ten or fifteen feet away it may be dry. Then, again, the readings of those low temperatures are very close together, and a slight personal error in taking the reading of either thermometer will throw the total experiment into a very doubtful realm.

Some time ago I attempted to solve, in a measure, the problem of measuring humidities at temperatures near freezing, and even very much below freezing, and I attempted an instrument that was based on these lines: I used a wet and dry bulb thermometer, the same as in a sling psychrometer, but placed them in a chamber, connected this chamber with a heating chamber, connected this heating chamber by a hose with the air at the point at which I wanted to sample the temperature and moisture. That, it seemed to me, would cut out the question of proximity of the body to the instrument. In other words, the air could be drawn out of the room, without there being anybody in the room, and forced over the wet and dry bulb thermometer. It could be heated on the way out, if necessary. If the air was at zero it could be heated, we will say, up to 35 or 40 degrees; and the specific moisture of the air at zero, even if it were near saturation, would give you at 35 or 40 degrees a very wide reading; in other words, that air would be relatively dry at 35 or 40 degrees. This seems to be a beautiful scheme—on the face of it it looked very nice. But there are a great many difficulties connected with it. In the first place, the means that I used to draw the air out and to circulate the air by fans were imperfect. I first attempted to draw the air through the complete circuit—that is, to have the suction fan at the bottom of the thermometer tube. I very soon found that there was a backlash on this fan, and that the air in the room in which the instrument was situated got mixed up with the air that was being drawn through the tube from the point where we wanted to handle it. I then tried another scheme—that of taking the air from the room to a fan and then driving it over the bulb. This gave me better results. It, of course, necessitated a calculation. That is to say, if the air showed a certain humidity at 40 degrees I could, by the use of the tables, calculate what that air would have been at 10 or 30 degrees above zero or zero. But I am sorry to say that the results are not as yet reliable. I knew in some cases that the air which I sampled was a great deal drier than it was shown by calculating back from the readings of this instrument. And so far as I know, Mr. President, there is no accurate instrument yet devised by which you can, in a short and simple operation, determine exactly the relative humidity of temperature at freezing or even up to 35 degrees. And there is no instrument devised that will accurately give you the humidity at lower temperatures. I venture to say that a man skilled in psychrometry can go into a cold storage room and he can give you any kind of humidity you want; and the more skilled he is in it the

more kinds of figures he can give you. Of that I am perfectly satisfied. Whether the instrument I spoke of will eventually work out or not, I am unable to say. I am still working on it. It seems on the face of it to be a good scheme, but I am sorry to say that as yet I do not regard the instrument as being—well, even approximately correct.

President Block.—The tables, Mr. Starr, that we have in our handbooks, are they calculated, do you know, or are they made up from actual measurements?

John E. Starr.—I think Mr. Ely can answer that.

James Ely.—They are all copied from the Weather Bureau Pamphlet No. 235. They were supposed to have been obtained by actual experiments, checking against the dew point apparatus and against a sling psychrometer, then they proved the same by a formula. If you will take the Weather Bureau pamphlet that I referred to and look it over very carefully from beginning to end, you will see that they have done a tremendous amount of work; but, like a great many other of the Government statistics, I think you will have hard work to believe all they say, because they take temperatures away below the freezing point, away below zero, with a sling psychrometer; and I doubt if there are any engineers here that can do it. As to how accurate it may be, I don't know. But they take it up as far as 400 degrees Fahr., and the relative humidity at that temperature is very hard to determine, necessarily; and it is equally as hard to determine at 50 degrees below zero.

Charles E. Lucke.—The bases of all this work in hygrometry are the thermo-dynamic laws of vapor gas mixtures, and any honest author of a thermo-dynamics will tell you that those laws are only approximately true. A dishonest author will not say anything about it, and that is the case with most of them. One of the most erratic laws which is assumed to be true is the Avogadro law, that the densities of gases and vapors are proportional to their molecular weights; and it is assumed to be true near the dew point for water vapor. There is ample evidence that water vapor does not behave as a gas near its point of condensation, no matter whether this is low or high. I consider, therefore, that the very fundamental basis of calculation is itself wrong, and the tables computed from it partake not only of the errors of the original theory, but also errors of observation, and that they are not to be relied upon, except as approximations—better, to be sure, than any other we can make, but, nevertheless, approximations. Until the laws of gas and vapor

mixture are in a better shape than they are at the present time there will be no possibility of improvement.

H. J. Krebs.—The basis of hydrometers seems to me to be the capacity of the air to evaporate liquids. Now, you reach the result, not by reading the evaporations, but by reading the refrigerating effect of the evaporation. Why can't you, by simply measuring directly the evaporation from certain surfaces, reach practical results far better and with simpler methods than you can through first evaporating and then reaching the effect in an indirect way by reading the refrigerating effect? Scales are so accurate, and you can so readily measure the loss by exposing a certain wet surface to the air and reweighing. You should then be able to get a direct result as to the capacity of the air to dry, and that is really what you want. I think I have made my thought plain.

John E. Starr.—I think, Mr. President, that the point here is a question of the availability of the psychrometer. There is no question about your ability to discover the amount of moisture contained in a cubic foot of air or a number of cubic feet of air. Several methods are used, but they are essentially close laboratory methods. What we are trying to arrive at is an instrument which one only fairly skilled can use and in a short time estimate closely the moisture in the air. A very simple means of getting at it, as far as the simplicity of the operation is concerned, is to use an aspirator—that is to say, fill a vessel of known capacity with water and connect the top of this vessel with a tube, this tube containing a certain amount or weight of drying material, such as chloride of calcium or sulphuric acid, or both. Then let the water run out of your aspirator—of course, not through the tube, but drawing through the tube from the room a known quantity of air and then weighing your drying material again. If such an operation is conducted by a man who knows how to weigh and who understands all the delicacy of the manipulation of the operation, you can arrive exactly at the specific moisture of the air, and from that, of course, the relative humidity. But that is an operation that takes time, skill, special knowledge and delicate scales and all that sort of thing, which throws it entirely outside of the means at the hands of the ordinary cold storage warehouse man or operator of any department where the humidity of the air is to be determined. What we want in an instrument is that within a few minutes you can quickly find the humidity of the air; and that instrument, I claim, has not yet been made for low temperatures, and for any temperatures below 35 degrees it is only an approximation.

President Block.—I think the matter of correctly gauging the amount of humidity in the air is very important to refrigerating engineers, and, judging from this discussion, there is a field open for the inventive genius. Besides, it seems that the tables we are using for figuring in connection with the cooling of air are not as accurate as they ought to be, and that we, therefore, should add a margin for safety.

A. E. Howe.—I would like to know if anyone present is familiar with the Milo Hastings apparatus? He was with the United States Department of Agriculture.

John E. Starr.—I know of the apparatus, but I don't know enough of it to describe it.

A. E. Howe.—As I understand it, the instrument consists of a horizontal porcelain tube filled with sulphuric acid. While the acid is not in direct contact with the air, the porosity of the tube makes this practically so. The absorption of moisture by the sulphuric acid affords the observer a means of determining the humidity.

Harold W. Cole.—It seems to me there was published in an official document of the United States Department of Agriculture a description of this instrument, so it seems to have some scientific standing with the Bureau of Chemistry or with the Agricultural Department, or they would not have put it out in just the form they did.

Gardner T. Voorhees.—Mr. Ely spoke of floating hydrometers, and I desire to say a word on this subject. I have seen tests, particularly on the absorption machine, where you attempt to get a strength of aqua, and have never seen any tests made that are really reliable with a floating hydrometer. It is not accurate. It is only accurate enough for rough, practical determination. The personal equation, the meniscus that comes up around the hydrometer stem, the temperature and other errors are such that almost every absorption machine strength of aqua test that I know of or have seen is wrong, unless the equivalent of the Westphal balance was used. The Westphal balance is a comparatively simple instrument for obtaining the strength of aqua ammonia. Tests without the Westphal balance would be absolutely unreliable, and they would have all to be discarded. Refrigerating engineers will have to establish a scale below 60 degrees, because that is too high. You have temperatures of liquor boiling at atmospheric pressure away down to 10 or 12 degrees, and must have a scale lower than these temperatures. It is comparatively easy to establish a —30 degree Fahr. scale, which you can easily obtain by cooling the aqua in a test tube

immersed in anhydrous ammonia. We know this is away down below 60 degrees atmospheric pressure, when not boiling.

James Ely.—I would like to ask Mr. Voorhees, in using the floating hydrometer, as he expresses it, how many degrees were on the scale and how graduated in Beaumé?

Gardner T. Voorhees.—That brings up the question of whether you have the true Beaumé scale or the standard chemist's scale, which is a different thing and has unequal degree divisions, or whether the hydrometer is properly standardized. The ones I have tried have, I should say, a scale six or eight inches long, and they gave results as close as any floating hydrometer; but there were errors or lack of exactness too considerable to allow any degree of accuracy in estimating the amount of refrigeration done between strong and weak liquors or of the strength of any liquor.

James Ely.—I would like to say there are instruments made with a per cent. scale for ammonia scaled from 10 to 38 degrees Beaumé, divided into four stems, each having a very small block, because it is only 10 to 38 degrees, and you can read very accurately to the third decimal place; but the fourth decimal place may carry a slight error. They cost about $10 each.

Gardner T. Voorhees.—That is all very well, but expensive, and still liable to many errors. You can buy a Westphal balance for less than $30, and have an accurate instrument, and you can have the specific gravities correct to the third-place decimal, and approximately so to the fourth-place decimal.

Charles E. Lucke.—I might add that I have a set of hydrometers, sixteen in number, giving the ordinary ranges, sometimes put on one standard. Each stem is about ten inches long, so the ordinary scale is extended to one hundred and sixty inches. There is no difficulty in reading four places, I think. It is a German product.

No. 79.

ADVANTAGES AND LIMITATION OF THE FLOODED SYSTEM.

By H. J. Krebs, Newport, Del.
(Non-Member of the Society)

It is, as you all will admit, no reflection on the flooded system to say that, in order to get the best results with this system, not alone the good points should be carefully developed, but the limitations of the system equally should be carefully studied, so as to avoid mistakes. Mr. H. Rassbach has given, in a recent paper, some valuable information in regard to this work and his views of this system, so I do not need, in a general way, to describe it. I think the principle may be considered as well known to the trade.

STORAGE TANKS SHOULD BE HIGH.

I think the reason that the flooded system has taken hold so tardily must be found in the fact that when the high pressure is removed from the refrigerant (in this paper we will consider this as being anhydrous ammonia, and speak of it as such), the energy of this liquid and its ease of circulation are at the same time removed, or at least materially diminished, so that the different units composing plants, which are not alone frequently separated from one another by considerable space, but also located at different levels, can no longer be fed with the same ease. With the energy of high-pressure ammonia, such units can all be readily reached from the anhydrous tank, supplied by the condensers, even if this tank is found in the basement of the buildings. This cannot, with certainty, be accomplished by the gravity system. The storage tank for the ammonia must here be placed at a higher level and the ammonia forced into it. However, in this case there would be no reason to resort to pumping, as the ammonia leaves the condensers under so high a pressure that it readily could be forced into any receiver, no matter where situated, before the pressure is reduced to that of the suction side of the system.

A STAND-PIPE ON THE RECEIVER.

We will, therefore, consider that the supply tank is placed at a high elevation above all the units of refrigeration, so that the an-

hydrous ammonia can flow from this tank to the different units. The next point to consider in regard to the distribution is that, by removing the energy from the refrigerant, you must necessarily resort to considerably larger sections of piping in order to enable enough of liquid to reach the units. At the same time, care must be taken that the evaporation going on within the mains through the absorption of heat does not take place to such an extent and under such circumstances as to prevent free circulation of the liquid; for it is self-evident that the liquor would flow to all lower pipe lines by gravity, provided the specific gravity of the liquor mixed with the gas is not reduced to such an extent as to prevent the anhydrous ammonia from flowing to the different coils where it is used. To insure this result, I believe that a large standpipe, well insulated, should be fitted to the receiver, preferably in a vertical position, of which the area is so large that the developed gases can readily escape in the contrary direction to the flow of the liquid.

From the lower part of this column the different units can be fed without fear of obstruction from the gases, provided these pipe lines either incline slightly upwards toward the unit, or at least are so constructed that no serious gas traps can occur that would prevent the flow of the liquid. Of course, when the whole plant is working with high energy and every unit is in operation, the plant probably would work well, even disregarding these rules, as the flow of the liquid ammonia would be sufficiently rapid and the development of gases sufficiently small so as not to obstruct this current; but where the operation either is less energetic or some units are out of operation, the gas traps, if not properly provided against, may cause delays and annoyance.

AVOID GAS TRAPS.

The next essential feature that must be covered in the flooded system is such a construction of the refrigerating units that will support the easy circulation of the liquid through them. The considerations here are practically the same as those governing the mains—namely, comparatively speaking, large sections and absence of traps. In the expansion coils the volume of the gas naturally increases with the distance from the entrance, and in very large units it might be advantageous to increase the diameter towards the outlet. With high-pressure feed, the liquid will find its way through the refrigerating coil, no matter what traps are in its way, but no such force is behind the liquid in the gravity system, for which reason much greater care in the construction of the pipe system is required.

I believe that I, in the foregoing, have outlined the essential limitations of this system. Mr. Rassbach, in his paper, has reflected on my "erroneous conceptions," and attributes to these the lack of success realized with this apparatus. To be sure! That erroneous conceptions have to be carefully guarded against I freely admit; but he is, nevertheless, in error in what he says.

Of course, when the anhydrous ammonia from the condenser is expanded into the low-pressure receiver there is a certain amount of spraying taking place, and I think that a well-constructed system of baffle plates, to retain the liquid of which Mr. Rassbach speaks, is very useful indeed. However, if precautions are taken, so that the spraying does not point directly to the suction pipe and the area of the receiver is large enough, the trouble from the spray is limited. I have known plants fitted in this manner that never carried frost all the way to the pumps.

REASONS THE SYSTEM DEVELOPED SLOWLY.

The reasons why the flooded system did not gain a firm footing promptly, I think, may be said to be three: First, I was only a refrigerating engineer *pro tempore,* having gone into it to help out a friend; secondly, the trade was not ready for this innovation, to which Mr. Louis Block, during the discussion of Mr. Rassbach's paper, bore testimony; and thirdly, a couple of plants put up by the late Mr. J. C. Mustard on this system, while quite successful in the start, developed defects later on, through the fact that the refrigerating coils contained a large number of sweated joints, and the tin, either by direct action of ammonia and brine, or perhaps through galvanic action, did not prove durable, so that the coils became so leaky that they had to be removed. As the people who operated these plants did not know enough to differentiate between the leaky coils and a flooded system, the latter was condemned, and, as I had other things to do than to swim against the current, I did not pursue it further.

SOME ADVANTAGES.

When we come to speak about the advantages of the flooded system, I think they are primarily two-fold. The one advantage must be sought in the fact that you get a higher efficiency from every square foot of refrigerating surface that you employ, and, consequently, can save materially on the first outlay—how much, I will not venture to say; my experience has not been great enough to demonstrate it. It will depend on the care and the skill with which the system is designed and erected, and will vary for each plant.

A second and, I believe, more important point is, that the back pressure at which the plant can be operated can be raised somewhat, for the nearer the refrigerating coils come to doing their utmost duty, the higher you can raise a back pressure without diminishing the efficiency of the system; and through this a corresponding economy in the first cost of your compressor can be realized, as you will be able to do the work with smaller cylinders, and secondly, you can thereby realize economy in the coal consumption—both very important items.

There is a third economy to be realized, though of minor importance—namely, that through carrying a lower pressure in your feed mains your loss through leakage is proportionately diminished. Economy in ammonia should also be realized through employing smaller refrigerating surfaces than you would do under the high-pressure feed system.

I believe, therefore, that I am correct in saying that you, with a carefully designed and carried-out system, will not alone be able to construct the plant for less money, but it can also be operated and maintained at a smaller cost.

The limitations of the system, however, must be carefully considered before you determine on taking it up, for the old high-pressure system, with all its defects, undoubtedly is the simplest; and as refrigerating engineers all know this system much better than they can know the flooded system, owing to the fact that it has not been used much, it is readily seen that the flooded system, for some time to come, must labor under the disadvantage of being less clearly understood.

DISCUSSION

R. L. Shipman.—I have made a number of tests on the flooded system under a great variety of conditions, and I considered this system far superior to the direct expansion system. I cannot agree with Mr. Krebs that the flooded system is more difficult to operate than the direct expansion. In my judgment, a good, well-designed flooded system can be operated with a much less efficient engineer than can the direct expansion.

President Block.—Would you suggest or approve of the flooded system for all classes of refrigeration?

R. L. Shipman.—No, sir; not for cold-storage work in general, but certainly for all ice-plant work. There are many cases where it is advisable to use the flooded system in cold-storage work.

President Block.—Whether they are plate or can plants?

R. L. Shipman.—Yes. There are some misleading statements in this paper as to the different special advantages of the flooded system—that is, you can get a higher back pressure, lower temperature of brine, do the work for less horsepower per ton and a few other advantages with the flooded system. A certain total saving is obtained by adopting the flooded system. Some saving can be secured in all of these factors or all the saving can be realized in one of them. For example, we can take a freezing tank that has been designed for the expansion method and equip it for the flooded system and run with the same temperature of brine with a considerably higher back pressure and thereby save considerable horsepower per ton, or we can take out some of the cooling surface and run the same temperature of brine with the same horsepower per ton, or we can design a new plant of the same ice-making capacity with about 30 per cent. less cooling surface and get the same back pressure and the same temperature of brine as we would with a more liberal amount of cooling surface with the direct expansion system.

President Block.—But you can cut down the number of cans and amount of cooling surface and increase the back pressure at the same time?

R. L. Shipman.—No; you can have one of these savings or a partial saving from all.

President Block.—If you leave the plant as it is, but flood the coils, you would produce somewhat more ice with the same plant?

R. L. Shipman.—Yes.

H. J. Krebs.—I will say that the pressure in the first part of a coil, with high-pressure feed, necessarily must be considerably higher than it is towards the end. In the flooded system the sectional area is so large that you should realize practically the same pressure throughout the coil, and, by realizing the same pressure throughout the coil, you get a uniform refrigerating effect from every square foot.

R. L. Shipman.—There would be some difference in pressure, but not as much as is generally assumed. I might state that I have recently built a coil containing about 1,100 feet of one and one-fourth-inch pipe near an accumulator, especially to test the efficiency for the flooded and the direct expansion methods. I have done considerable testing in a qualitative way, but I have no test in a quantitative way. I found that that coil will operate very successfully with the flooded system, although the top of the coil stands within three feet of the top of the accumulator. It operates very regularly,

and I have made some unsuccessful attempts to get it to operate regularly under the direct expansion method.

H. J. Krebs.—In regard to the circulation, I would say that I considered principally the gravity feed in my paper. There are, of course, possibilities of using pumps to very good effect, only the pumps complicate the matter some.

R. H. Tait.—I have a curiosity to know whether it has ever been tried to connect a flooded unit and an expansion unit to the same return pipe.

R. L. Shipman.—I would say there is absolutely no reason why they should not be worked together, because the accumulator, if properly operated, will prevent any liquid from entering the compressor. The best practice with the flooded system is to put gauge glasses on the accumulator, and the engineer judges by the liquid in the gauge glass, not by the back pressure, when he has enough liquid in the system. That is the reason it is simpler and easier to operate than the direct expansion system.

Irving Warner.—I am not familiar enough with this system to make an explanation of it or make any remarks on it, but last year we had quite a discussion with our friend Mr. Shipley in regard to the question of running pipes in series. Mr. Krebs spoke just now about the higher pressure which exists at the point of expansion, and I said at that time that we never carried any tests on that ourselves, because the various sections in series operated successfully as they were. I would like to have Mr. Krebs inform me on the following three points: First, where does the gas go that is generated in the pipes? Does it go back through the same pipe or does it go on out through the other end of the pipe and ultimately combine with the gas from the top of the receiver? Second, in feeding a coil of horizontal pipe, will the feed go in at the bottom and go back and forth upwardly to discharge at the top? Third, would it be possible to place several coils having horizontal pipes above and in series with each other without tapping off the gas between those coils?

H. J. Krebs.—I said in my paper that I thought it would be proper to lead a large, vertical main from the accumulator or receiver of the ammonia. With such a large main the gases would have an opportunity to escape up, while the liquid would flow down the same pipe. From the base of the standpipe horizontal feed mains could be fitted in different directions for the different units. In horizontal pipes the gas has not any longer a chance to escape from the liquid, but must follow the current. That was, I think,

the first question you asked, and the last was regarding horizontal coils. Of course, the feed has to go to the bottom, and then there is no trouble in feeding the coils. You have all the time more pressure on the side where the coil is fed. There is, under normal conditions, much less gas on the feed side than there is in the other end of the coil. Now, both ends of the coil originate at the same height from the receiver; consequently, on the feed pipe there must be, on the whole, more pressure, and it is all the time ready to drive the gas out the opposite way. But, naturally, you have to allow larger sections. I think I understood your questions properly, but if I did not it is because I do not hear so well.

Irving Warner.—Just one other question, Mr. Krebs. In a plate ice plant with direct expansion—of course, having a great number of plates—would you let each plate have its own flooded liquid feed and discharge back to the receiver, or would you run three or four or five plates to one section without tapping the gas off between the plates?

H. J. Krebs.—Well, I believe that in very large plants that it would be proper to supply several feeds and several feed mains. They might originate from the same receiver.

President Block.—You want to know, Mr. Warner, whether it would be advisable to feed four or five coils in series, or whether you would feed four or five in parallel; isn't that the idea?

Irving Warner.—That is the idea. Of course, I realize that even if they are in series the gas must be tapped off between the high points.

President Block.—It depends, however, entirely upon the size of the pipe you employ. If you had four-inch pipe coils you would not, perhaps, need to do it, but with inch-pipe coils you would need to tap.

H. J. Krebs.—I would like to say there isn't any reason to feed in series with the flooded system, because you have no waste of ammonia. It would flow into the receiver and go into operation again. Therefore, even if each unit is fed with more liquid than it can consume, it gives no loss. That is one of the advantages of the flooded system; you cannot overfeed. One of the great drawbacks of the high-feed or direct-expansion system is that you cannot feed enough, for if you do you have a waste. Now, I have no interest in the flooded system, and I realize that the other system—the high-pressure feed—is much simpler. But I still have faith in the flooded

system, and I do believe that where it is given careful thought and handled properly it will come out ahead.

Irving Warner.—How do you work it, Mr. Krebs, to cut one plate off entirely? Do you put in the ordinary throttle valve and close off?

H. J. Krebs.—Yes; an ordinary gate valve.

Irving Warner.—A float valve, I suppose, and one on the gas line also?

H. J. Krebs.—Of course, those are details that would vary with the different plants; but I should think gate valves on both sides, inlet and outlet, would be a simple thing. There is, of course, some trouble connected with the system, not alone the gas traps, but also your water traps. Of course, you don't get any water with your anhydrous ammonia, but sometimes the suction side will have leaks. Then you have to deal with water in your coils, and, naturally, water being heavier than ammonia, it will gravitate to the expansion coils. Oils also are apt to accumulate, and you would have to take sufficient precautions, being able to blow through those coils in such a way as to get rid of the accumulations. I suppose that ought to be done periodically, but that all depends upon the care with which the oil and water are eliminated from the feed.

Edgar Penney.—Mr. Krebs, are you familiar with the original Pictet refrigerating system?

H. J. Krebs.—In a general way.

Edgar Penney.—Would you call that a flooded system?

H. J. Krebs.—I don't know. Was not a similar system patented by Pictet?

Edgar Penney.—The original arrangement of the Pictet refrigerating system, which is probably one of the most efficient evaporators that has been used, is a horizontal cylinder filled with tubes, having three domes. The cylinder is filled half or two-thirds, or nearly full, with the liquid. The compressor was connected to the center dome, and the liquid flowed through a regulating valve from the condenser to this cylinder. The gas is aspirated from the refrigerator by the compressor pump and the brine is forced through the tubes. Now here is a large body or flood of liquor, the gas being drawn off as fast as evaporated. That is a flooded system, is it not?

H. J. Krebs.—I should think so.

President Block.—Well, whether it is the flooded system de-

pends largely on whether you admit the liquid by expansion valves or ordinary liquid or stop valves.

Edgar Penney.—Simply flowed into it the same as a boiler feed.

President Block.—Then it would be the same as the flooded system?

Edgar Penney.—Kept up to a level as shown by a gauge.

IN MEMORIAM

	Born	Died
Blethen, Henry,	February 27, 1857	April 24, 1909
Boyer, Francis H.,	September 6, 1845	February 21, 1909
Collins, John Glenn,	July 28, 1854	April 19, 1908
Gould, Ovid M.,	April 23, 1838	February 21, 1911
Hier, Frank T.,	July 6, 1859	February 2, 1912
King, Rockwell,	1853	July 27, 1905
Maschwitz, Carlos.	May 7, 1862	1911
Siebert, Alfred,	1853	July 20, 1909
Smart, John M.,	August 8, 1866	April 14, 1912
Smith, Edmund J.,	October 21, 1856	September 17, 1906
Tough, L. M.,	1846	April 15, 1911
White, Frank H.,	September 22, 1874	May 26, 1907
Willis, James,	April 30, 1845	March 29, 1910

LIST OF MEMBERS

*Abbey, Frank H. (1908), 7 Pelham Terrace, Arlington, Mass.
Aday, F. M. (1911), Fred W. Wolf Company, 50 Church street, New York, N. Y.
§Affleck, William B. (1906), Keystone Engineering Works, 719 Noble street, Philadelphia, Pa.
*Allen, Philip R. (1905), F. W. Bird & Son, East Walpole, Mass.
Allison, C. E. (1911), Shipley Construction & Supply Company, 72 Trinity place, New York, N. Y.
Armour, Norman H. (1911), 6103 Normal boulevard, Chicago, Ill.
Armstrong, C. G. (1911), 149 Broadway, New York, N. Y.
Ashton, Walter S. (1907), St. Louis Brewing Association, 703 Wainright building, St. Louis, Mo.
*Atwood, John C. (1905), The National Ammonia Company, 3600 North Broadway, St. Louis, Mo.
Aue, J. E. (1904), De La Vergne Machine Company, foot of East One Hundred and Thirty-eighth street, New York, N. Y.
§Baars, Ernst S. H. (1907), Vilter Manufacturing Company, 872 Clinton street, Milwaukee, Wis.
§Bachniski, Charles G. (1911), 672 Buffum street, Milwaukee, Wis.
Baer, Alvin H. (1905), Frick Company, Waynesboro, Pa.
Ball, P. D. C. (1904), (Vice-President 1905-'06), 3003 North Broadway, St. Louis, Mo.
Bates, Guy (1909), 90 West street, New York, N. Y.
Bauer, Ferdinand (1911), 4131 Meramac street, St. Louis, Mo.
§Bavier, Robert N. (1909), Knickerbocker Ice Company, 1170 Broadway, New York, N. Y.
*Bavier, William N. (1909), Knickerbocker Ice Company, 1170 Broadway, New York, N. Y.
Becker, Jr., Victor H. (1909), Pilsbry-Becker Engineering Company, 200 Mo.
Becker, Jr., Victor H. (1909), Pilsbry-Becker Engineering Company, 200 North Main street, St. Louis, Mo.
Behn, Carl (1904), (Director), Buffalo Refrigerating Machine Company, 126 Liberty street, New York, N. Y.
Bein, G. F. (1909), 602 Wheat building, Forth Worth, Tex.
Berna, George (1904), 4217 Russell avenue, St. Louis, Mo.
*Berryman, Robert J. (1909), Annapolis, Md.
Bertsch, J. C. (1904), P. O. Box 417, Fort Worth, Tex.
*Binzel, Jr., Peter (1909), United Cork Companies, 50 Church street, New York, N. Y.

Bishop, A. C. (1907), Great Lakes Engineering Works, foot of Rivard street, Detroit, Mich.

Block, Louis (1904), (Director 1905-'08, President 1909, Director), 45 East Forty-second street, New York, N. Y.

Borchers, Herbert L. (1911), 3839 St. Louis avenue, St. Louis, Mo.

Borgstedt, Henning N. (1905), 67 Park avenue, Yonkers, N. Y.

*Bost, William David Ashton (1906), Cartvale Chemical Works, Paisley, Scotland.

Botchford, H. J. (1905), Carbondale Machine Company, 1329 Candler building, Atlanta, Ga.

*Bower, William H. (1911), Henry Bower Chemical Manufacturing Company, 2815 Gray's Ferry road, Philadelphia, Pa.

*Bowers, James (1910), 106 West Eighteenth street, Wilmington, Del.

*Bracken, J. H. (1908), Union Fibre Company, Winona, Minn.

*Bridgette, R. E. (1911), 261 Bond street, Brooklyn, N. Y.

*Briggs, John N. (1907), Coeymans, N. Y.

§Broas, Richard S. (1910), Starr Engineering Company, 50 Church street, New York, N. Y.

Brostrom, Gustav R. (1909), 529 Linden avenue, York, Pa.

*Brownell, C. H. (1905), Washington Court House, Ohio.

*Burhorn, Edwin (1905), 71 Wall street, New York, N. Y.

Carpenter, Martin R. (1904), Triumph Ice Machine Company, Oakley, Cincinnati, Ohio.

*Case, Charles L. (1904), (Director), Boston Terminal Refrigerating Company, 239 Sumner street, East Boston, Mass.

§Cavnah, H. E. (1907), 1226 Eddy street, San Francisco, Cal.

Chatard, William M. (1909), Chatard & Norris, 1412 Continental building, Baltimore, Md.

Church, Fred B. (1904), 10 Bridge street, New York, N. Y.

Cochran, Heywood (1909), Carbondale Machine Company, 431 South Dearborn street, Chicago, Ill.

§Cole, Donald (1907), 606 Meyer avenue, Canton, Ohio.

*Cole, Harold W. (1904), 9 Mountain Terrace, Upper Montclair, N. J.

Cooper, Madison (1904), (Director 1909-'11), Calcium, N. Y.

*Criss, Charles L. (1906), Liberty and Second avenues, Pittsburgh, Pa.

Criswell, A. P. (1904), P. O. Box 435, Chicago, Ill.

*Croll, Cecil H. G. (1905), Shannon street, Island Bay, Wellington, N. Z.

Daly, Benjamin F. (1905), Hollands, Rockaway Beach, N. Y.

§Day, Abram (1910), 160 Williamson avenue, Bloomfield, N. J.

De Hart, Jr., John S. (1904), Isbell-Porter Company, 46 Bridge street, Newark, N. J.

De Kinder, J. J. (1904), (Director 1907-'09), Franklin Bank building, Philadelphia, Pa.

§Delareuelle, G. H. (1909), United Iron Works, Railroad and Stevens streets, Spokane, Wash.

§Delle, Frank A. (1907), 4410 Pennsylvania avenue, St. Louis, Mo.

Dettmar, E. (1908), 6254 Jackson Park avenue, Chicago, Ill.

Dickerman, Charles (1904), (Director), Twenty-sixth street and Susquehanna avenue, Philadelphia, Pa.

§Dickinson, Raymond N. (1907), Boonton Electric Company, Boonton, N. J.

Doelling, Louis (1908), (Director), De La Vergne Machine Company, foot of East One Hundred and Thirty-eighth street, New York, N. Y.

Dorr, A. L. (1907), Armstrong Cork Company, 84 North street, Boston, Mass.

*Dreyer, Oscar (1911), Rjasan Ooralsk Railway, Saratov, Russia.

*Dunning, George A. (1910), Standard Ice Manufacturing Company, Twenty-seventh and South streets, Philadelphia, Pa.

*Ely, James (1905), Hohmann & Maurer Manufacturing Company, 31 Union Square, New York, N. Y.

§Fagnan, D. L. (1906), 533 East One Hundred and Thirty-ninth street, New York, N. Y.

*Feilberg, Nicolai L. (1910), 4058 Kenmore avenue, Chicago, Ill.

Fisher, George H. (1909), Leavenworth, Kan.

Flocke, Frank J. (1904), 791 East One Hundred and Seventy-fifth street, New York, N. Y.

Fowler, A. M. (1910), United Iron Works, 151 North Los Angeles street, Los Angeles, Cal.

Frantz, Samuel R. (1905), 219 West Main street, Waynesboro, Pa.

Frick, Ezra (1904), Clayton avenue, Wayneboro, Pa.

Friedmann, Edward N. (1904), (Director 1910, President 1911, Director), 90 West street, New York, N. Y.

Gallenkamp, Jr., Edward W. (1911), St. Louis Refrigerating & Cold Storage Company, St. Louis, Mo.

Gardiner, Edward J. (1906), Harrow road, Bexley, Sydney, New South Wales, Australia.

Geisler, George H, (1909), United Iron Works, Second and Jefferson streets, Oakland, Cal.

*Glover, J. Graham (1905), 166 State street, Brooklyn, N. Y.

*Golden, Albert J. (1908), Industrial Cold Storage & Warehouse Company, American and Berks streets, Philadelphia, Pa.

Goodmanson, Frank A. (1907), La Plata Cold Storage Company, Ltd., Pureto La Plata, Argentine Republic.

Goosmann, J. C. (1904), 172 Washington street, Chicago, Ill.

Gray, John Lathrop (1909), Tide Water Oil Company, East Twenty-second street, Bayonne, N. J.

§Greene, Van Rensselaer H. (1905), De La Vergne Machine Company, foot of East One Hundred and Thirty-eighth street, New York, N. Y.

§Guckel, Charles H. (1906), Springfield Gas & Electric Co., Woodruff building, Springfield, Mo.

Hague, John (1911), 1228 Pine street, St. Louis, Mo.

*Haire, David E. (1905), 1532 Land Title building, Philadelphia, Pa.

Hargreaves, William (1905), De La Vergne Machine Company, foot of East One Hundred and Thirty-eighth street, New York, N. Y.

*Hausmann, Carl (1909), 13 Featherstone Terrace, Wellington, N. Z.

Haven, Harry M. (1904), F. W. Dean, Inc., 53 State street, Boston, Mass.

Havenstrite, Charles D. (1908), H. W. Johns-Manville Company, 322 North Michigan avenue, Chicago, Ill.

*Herst, Franklin H. (1905), Twenty-ninth and Market streets, Philadelphia, Pa.

*Hexamer, William E. (1908), Vilter Manufacturing Company, 864 North Franklin street, Philadelphia, Pa.
§Hill, John (1911), York Manufacturing Company, York, Pa.
*Hill, Walter L. (1905), 110 State street, Boston, Mass.
Hiller, N. H. (1904), (Director 1909-'11), Carbondale Machine Company, Carbondale, Pa.
§Hoffman, C. E. (1907), Hotel Bristol, Houston, Tex.
§Hoffmann, W. John (1911), 1014 Washington street, Hoboken, N. J.
Holden, D. L. (1904), 1919 Seventh avenue, New York, N. Y.
*Holzbaur, W. L. (1907), 2610 Brooklyn avenue, Kansas City, Mo.
*Hoos, William (1907), 143 North Front street, Philadelphia, Pa.
*Horne, Frank A. (1907), (Treasurer), 161 Chambers street, New York, N. Y.
*Horne, George A. (1911), 161 Chambers street, New York, N. Y.
Hoshino, Ichizo (1911), Takata & Co., Ichome Yurakucho, Tokyo, Japan.
*Hovey, Charles A. (1909), United Cork Companies, 50 Church street, New York, N. Y.
*Hughes, John L. (1909), Yakima Artificial Ice & Cold Storage Company, North Yakima, Wash.
Hunter, George C. (1907), 1392 West Third street, Cleveland, Ohio.
Huntley, Clifford E. (1908), 103 Park avenue, New York, N. Y.
Jacobus, D. S. (1904), (Director 1905-'06, President 1907), Babcock & Wilcox Company, 85 Liberty street, New York, N. Y.
§Jaeger, A. P. (1908), 2122 California street, Omaha, Neb.
§Jamison, Jr., J. V. (1908), Jones Cold Store Door Company, Church and Foundry streets, Hagerstown, Md.
Jenks, L. Howard (1904), (Director 1905-'07), Frick Company, 39 Cortlandt street, New York, N. Y.
*Johnson, Albert (1906), 2635 Hampden court, Chicago, Ill.
§Karl, Robert H. (1910), 4620 Vernon avenue, St. Louis, Mo.
Kerbel, C. Joseph (1910), Central Consumers Company, Louisville, Ky.
Kilian, Justus (1907), Vilter Manufacturing Company, 872 Clinton street, Milwaukee, Wis.
Kolischer, Theodore (1907), Central Construction & Supply Company, 140 North Tenth street, Philadelphia, Pa.
Kremer, Waldemar R. (1907), Vilter Manufacturing Company, Milwaukee, Wis.
Krum, Charles L. (1904), 421 North State street, Chicago, Ill.
Laichinger, John (1911), 1214 Liggett building, St. Louis, Mo.
Lane, George H. (1910), Shipley Construction & Supply Company, 72 Trinity place, New York, N. Y.
Langley, Frank W. (1911), United Iron Works, 151 North Los Angeles street, Los Angeles, Cal.
Levey, John (1904), National Machine Works, North and Sheffield avenues, Chicago, Ill.
*Lewis, Eugene W. (1907), 977 Fox street, New York, N. Y.
§List, Leonardo J. (1908), 864 North Franklin street, Philadelphia, Pa.
*Livezey, John R. (1907), 1933 Market street, Philadelphia, Pa.
*Loney, Luxton (1906), Equitable building, Sydney, Australia.

*Long, E. L. (1911), Armstrong Cork Company, Powers building, Rochester, N. Y.
Louis, J. S. (1904), Triumph Ice Machine Company, Oakley, Cincinnati, Ohio.
Lucke, Charles E. (1908), (Vice-President 1910-'11), Columbia University, New York, N. Y.
§Luedicke, Alexander H. (1911), 1011 Richards street, Milwaukee, Wis.
Luhr, Otto (1906), 1019 Irving Park boulevard, Chicago, Ill.
*Lynch, John H. (1907), 17 South William street, New York, N. Y.
*McCarthy, George L. (1904), 116 Nassau street, New York, N. Y.
*McDaniel, Homer (1905), (Vice-President 1909-'10), Sheriff Street Market & Storage Company, 2235 East Fourth street, Cleveland, Ohio.
*McDougall, A. M. (1909), Northern Cold Storage & Warehouse Company, Seventh avenue, West, and Railroad street, Duluth, Minn.
§McKee, Thomas C. (1907), Carbondale Machine Company, 431 South Dearborn street, Chicago, Ill.
*McPartlin, Stephen E. (1905), 20 West Jackson boulevard, Chicago, Ill.
*McPike, Eugene F. (1909), Railroad Refrigerator Service Association, 135 Park row, Chicago, Ill.
Manns, W. H. (1904), (Director 1909-'11), 219 West Second street, Waynesboro, Pa.
Markel, E. J. (1905), Room 30, 739 Chapel street, New Haven, Conn.
Marshall, A. T. (1909), 53 Oakland Terrace, Hartford, Conn.
*Marshall, Lewis C. (1905), 178 Devonshire street, Boston, Mass.
Matthews, F. E. (1904), Leonia avenue, Leonia, N. J.
Mayer, Fred W. (1908), Mayer Ice Machine & Engineering Company, Jersey City, N. J.
*Meeske, William (1911), 700 East One Hundred and Sixty-third street, New York, N. Y.
Meltzer, Arthur (1905), 418 H. W. Hellman building, Los Angeles, Cal.
Miller, Edward F. (1910), Massachusetts Institute of Technology, Boston, Mass.
*Moore, Herbert (1907), 99 South Front street, Memphis, Tenn.
Moore, Hervey M. (1907), United Iron Works Company, Springfield, Mo.
*Morgan, William Fellows (1905), Arch 5, Brooklyn Bridge, New York, N. Y.
Morris, O. J. (1905), Wilson building, Dallas, Tex.
Morse, Louis S. (1909), York Manufacturing Company, York, Pa.
*Morton, William P. (1907), Henry Bower Chemical Manufacturing Company, Philadelphia, Pa.
Neff, Peter (1904), 406 High street, Canton, Ohio.
Neubecker, Jean (1908), 347 East One Hundred and Thirty-ninth street, New York, N. Y.
*Nickerson, J. F. (1904), 431 South Dearborn street, Chicago, Ill.
Nordmeyer, L. C. (1904), 1214 Liggett Building, Eighth and Chestnut streets, St. Louis, Mo.
Nottberg, William (1905), 3415 St. John avenue, Kansas City, Mo.
Nulsen, Herbert S. (1909), 90 West street, New York, N. Y.
Odermann, E. H. (1905), Frick Company, Waynesboro, Pa.

Palmer, C. C. (1904), Railway & Stationary Refrigerating Company, 11 Pine street, New York, N. Y.

*Parsons, Charles H. (1907), 343 Bridge street, Springfield, Mass.

Parsons, W. Everett (1904), (Director 1905, President 1906), 818 Degraw avenue, Newark, N. J.

Patitz, G. J. (1909), Peter Schoenhofen Brewing Company, 526 West Eighteenth street, Chicago, Ill.

Penney, Edgar (1904), (Director 1905-'07, President 1908), Newburgh Ice Machine & Engine Company, Newburgh, N. Y.

§Phillips, E. A. (1911), 140 North Tenth street, Philadelphia, Pa.

Phillips, Ellis L. (1904), (Director 1905-'06), 50 Church street, New York, N. Y.

*Phillips, Louis A. (1909), Mitchell-Tappen Co., 149 Broadway, New York, N. Y.

Pilsbry, F. W. (1904), (Director 1907-'09), 1332 Monadnock building, Chicago, Ill.

Plock, John L. (1910), Ruemmeli-Dawley Manufacturing Company, 30 Church street, New York, N. Y.

Pownall, H. D. (1907), Arctic Ice Machine Company, Canton, Ohio.

§Prell, John S. (1907), 1137 Geary street, San Francisco, Cal.

Pryor, Frederick L. (1911), Stevens Institute of Technology, Hoboken, N. J.

Qualtrough, B. F. (1911), 321 Reliance building, Kansas City, Mo.

*Quigley, James Edwin (1905), 466 South Rebecca street, Pittsburgh, Pa.

*Reid, Walter C. (1904), (Treasurer 1905-'11), 32 East Forty-second street, New York, N. Y.

*Reilly, James P. (1905), 17 Battery place, New York, N. Y.

Rey Basadre, J. S. (1906), 569 Avenida Quintana, Buenos Aires, Argentine Republic.

Richardson, George P. (1911), Isbell-Porter Company, 46 Bridge street, Newark, N. J.

*Richmond, Herbert (1911), Union Fibre Company, 90 West street, New York, N. Y.

Riley, William H. (1908), Remington Machine Company, Wilmington, Del.

Robertson, G. A. (1907), Merchants' Ice & Cold Storage Company, Brook and Main streets, Louisville, Ky.

*Rodgers, Charles W. (1911), 701 West One Hundred and Thirty-first street, New York, N. Y.

Roelker, H. B. (1904), (Vice-President 1905, Director 1906-'08), 41 Maiden lane, New York, N. Y.

§Roos, Frank J. (1906), 239 Sumner street, East Boston, Mass.

*Rose, Clarence E. (1911), 500 East Sixth street, Little Rock, Ark.

Rosener, Leland S. (1910), 1129 Merchants' Exchange building, San Francisco, Cal.

*Ross, William H. (1904), (Secretary), 154 Nassau street, New York, N. Y.

Rowe, Samuel J. (1904), 233 East Main street, Waynesboro, Pa.

*Roy, L. A. (1911), Rector building, Chicago, Ill.

*Ruddick, John A. (1906), Dairy and Cold Storage Commissioner, Ottawa, Canada.

Ruemmeli, Albert (1909), (Vice-President), Ruemmeli-Dawley Manufacturing Company, 3900 Chouteau avenue, St. Louis, Mo.

§Sandholt, Walter W. (1909), 3965 Wilda Vale avenue, Oakland, Cal.
Schadek, E. W. (1905), Ruemmeli-Dawley Manufacturing Company, 3900 Chouteau avenue, St. Louis, Mo.
Schmidt, Louis M. (1904), 84 West Main street, New Britain, Conn.
§Schulte, Charles F. (1911), 2723 Bennett court, St. Louis, Mo.
*Seigle, Joseph (1911), 417 East Court street, Cincinnati, Ohio.
*Serrill, Horace P. (1905), 411 North American street, Philadelphia, Pa.
*Sethman, George H. (1909), 647 Williams street, Denver, Col.
Shipley, Samuel J. (1904), 72 Trinity place, New York, N. Y.
Shipley, Thomas (1904), (Director 1905-'11, President), York Manufacturing Company, York, Pa.
Shipley, William S. (1906), 72 Trinity place, New York, N. Y.
*Smith, Guy B. (1907), 306 St. James place, Brooklyn, N. Y.
*Smith, Morgan B. (1911), 109 Pharis street, Syracuse, N. Y.
*Sparks, John C. (1906), 30 Church street, New York, N. Y.
Starr, John E. (1904), (President 1905, Vice-President 1906-'07, Director 1908), 50 Church street, New York, N. Y.
*Stephens, Jr., L. H. (1907), St. Louis Refrigerating & Cold Storage Company, Lewis and O'Fallon streets, St. Louis, Mo.
Sterrett, A. W. (1909), Pacific Cold Storage Company, Tacoma, Wash.
*Stevenson, S. P. (1907), 1500 West Fourth street, Chester, Pa.
*Stockman, O. S. (1909), Armstrong Cork Company, Union Bank Building, Pittsburg, Pa.
*Stone, Junius H. (1906), Johns-Manville Company, Madison avenue and Forty-first street, New York, N. Y.
Stratton, Harrison D. (1908), 2610 Callowhill street, Philadelphia, Pa.
Strickler, A. B. (1906), York Manufacturing Company, York, Pa.
Tait, Roderick H. (1907), (President 1910), Liggett building, St. Louis, Mo.
Takahashi, Torata (1911), Teikoku Reizo Kabushiki Kwaisha, 12 Akashicho, Tsukiji, Tokyo, Japan.
Taylor, John R. (1907), 613 South Ervay street, Dallas, Tex.
Taylor, Walter A. (1907), P. O. Box 461, Hammond, La.
Thompson, Edgar W. (1905), Boyd's Ice Factory, Bombay, India.
Thompson, M. W. (1907), Greensboro, N. C.
*Tihotsky, Constantin (1911), 77 Sergierskay street, St. Petersburg, Russia.
*Tinker, Henry W. (1905), 41 Richmond street, Boston, Mass.
Torrance, Jr., Henry (1904), (Director 1905-'07, Vice-President), 50 Church street, New York, N. Y.
Trautwein, Alfred P. (1904), Carbondale Machine Company, Carbondale, Pa.
*Turner, Charles L. (1905), 411 North American street, Philadelphia, Pa.
Uchimura, Tatsujiro (1908), 10 Yariyacho, Kiobashiku, Tokyo, Japan.
Vesterdahl, Karl (1904), (Vice-President 1908-'09), 90 West street, New York, N. Y.
Vilter, Theodore O. (1908), (Director), 872 Clinton street, Milwaukee, Wis.
Vogt, Henry (1904), Henry Vogt Machine Company, Louisville, Ky.
Vollmann, Carl W. (1904), The Linde Canadian Refrigerating Company, 37 St. Peter street, Montreal, Can.
Von Weise, Louis B. (1911), 3003 North Broadway, St. Louis, Mo.
Voorhees, Gardner T. (1904), (Director), Engineers' Club, 32 West Fortieth street, New York, N. Y.

Voss, Bernhard (1904), 427 East One Hundred and Fortieth street, New York, N. Y.

Wait, John C. (1904), (Director 1908-'10), 38 Park row, New York, N. Y.

Waite, Nelson J. (1907), Sheriff Street Market & Storage Company, Cleveland, Ohio.

Walter, Bruce (1907), 6823 Thomas boulevard, Pittsburgh, Pa.

§Warner, Irving (1906), Charles Warner Company, Wilmington, Del.

*Webber, W. J. (1910), Cochrane Chemical Company, 40 Central street, Boston, Mass.

§Weddell, George O. (1911), 140 North Tenth street, Philadelphia, Pa.

Wegemann, Karl (1904), (Director 1908-'10), Ice Cream Construction Company, 90 West street, New York, N. Y.

Wells, George E. (1911), Anheuser-Busch Brewing Association, St. Louis, Mo.

*Werliin, L. (1905), 2815 Gray's Ferry road, Philadelphia, Pa.

Whelan, Robert A. (1904), 5745 Wabash avenue, Chicago, Ill.

*Whittemore, Clinton L. (1911), 48 Gay building, Third and Pine streets, St. Louis, Mo.

*Whitten, William M. (1907), Armstrong Cork Company, Pittsburgh, Pa.

*Widmann, F. (1906), Wainwright building, St. Louis, Mo.

Williams, E. T. (1911), Westerberg & Williams, 90 West street, New York, N. Y.

Williams, Llewellyn (1904), (Director 1907-'09), United Fruit Company, 131 State street, Boston, Mass.

Winborg, Abel (1906), 428 Park street, York, Pa.

§Wittemann, Rudolph W. (1905), Wittemann Brothers, 188 William street, New York, N. Y.

Wittenmeier, Fred (1910), 470 West Erie street, Chicago, Ill.

§Wolf, Carl B. (1906), 511 Denckla building, Eleventh and Market streets, Philadelphia, Pa.

Wolf, Jr., Fred W. (1904), 10529 Ashbury avenue, N. E., Cleveland, Ohio.

Wolf, Otto C. (1904), 511 Denckla building, Eleventh and Market streets, Philadelphia, Pa.

Woodcock, Willard J. (1905), 13 Cambridge place, Brooklyn, N. Y.

Woods, Arthur R. T. (1905), The Red Cottage, West Hill, Harrow, Middlesex, England.

*Wright, George W. (1907), Baltimore Refrigerating & Heating Company, 426 South Eutaw street, Baltimore, Md.

Wuertenbaecher, John J. (1908), 3315 Russell avenue, St. Louis, Mo.

Young, Conrad H. (1906), Armstrong Cork Company, 50 Church street, New York, N. Y.

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* Associate Member.

§ Junior Member.

Names without reference marks are Members.

Figures in parentheses, as (1904), immediately following the name, denote year of admission.

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